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s inexpensive hydraulic stylus-controlled equipment can adapted, in most cases, to suit existing machines when es may be machined quickly in accordance with the file of a master template or sample workpiece. The racy obtained is independent of the skill of the operator. equipment is available in a variety of forms and sizes for new and existing machines such as lathes, milling chines, boring mills and planers.

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THE ENGINEER

ESTABLISHED 1856

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PRINCIPAL CONTENTS

(Complete contents on page 162)

An Encouraging Degree of Unanimity 162

Some Notes on the Development of Fairground Machinery—No. III 146
(P. W. BRADLEY)

Determination of Economic Steam Cycle for Nuclear Power Stations—No. II 148
(P. H. MARGEN)

Plants for the Production of Anti-Knock Compounds —No. II 151

Explosion Characteristics of a Lubricating Oil Mist 165
(J. H. BURGOYNE, D. M. NEWITT, A. THOMAS)

Rye House Generating Station 155

Integration of Hydro and Thermal Generation in Great Britain—No. I 158
J. D. PEATTIE AND A. A. FULTON)

Refuse, Sludge and Compost in Agriculture ... 162

NOTICE TO READERS
All letters intended for insertion in 'The Engineer' or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications. No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

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Advertisements received by Mid-day Tuesday will appear in the issue of Friday the same week. Orders must be accompanied by a remittance.

INDEX TO ADVERTISERS—PAGE 119

PUBLIC APPOINTMENTS

WIGAN AND DISTRICT MINING AND TECHNICAL COLLEGE

(AMENDED ADVERTISEMENT)

LECTURER IN MECHANICAL ENGINEERING

Applications are invited for a post as LECTURER IN MECHANICAL ENGINEERING. Duties will commence as soon as possible.

Candidates should hold a good Honours Degree (or equivalent qualification) in Mechanical Engineering and have practical experience in industry and in teaching. Ability to teach one or both of the following subjects would be an advantage ; Workshop Technology to Higher National Certificate, and Diploma standard and Trade Technology to C.G.L.I. Machine Shop Engineering Certificate standard. Salary in accordance with the Burnham Technical Scale for Assistants, Grade " A " or " B," according to qualifications and experience.

Further particulars and application form will be sent by the undersigned on receipt of a stamped, addressed foolscap envelope. Applications should be sent in to reach the undersigned not later than Monday, 16th August, 1954. Applications not on the form provided will be disregarded.

E. C. SMITH,
Principal.

22nd July, 1954. E9852

THE UNIVERSITY OF LIVERPOOL

DEPARTMENT OF MECHANICAL ENGINEERING

LECTURER

Applications are invited for the post of LECTURER in the Department of Mechanical Engineering. Preference will be given to candidates with special interests in strength of materials. Salary within the range £550–£1100 per annum, according to qualifications and experience.

Applications, stating age, qualifications and experience, together with the names of three referees, should be received not later than 21st August, 1954, by the undersigned, from whom further particulars may be obtained.

STANLEY DUMBELL,
E9727 Registrar.

THE UNIVERSITY OF LIVERPOOL

DEPARTMENT OF METALLURGY

LECTURER

Applications are invited for the post of LECTURER in the Department of Metallurgy, at an initial salary within the range £550–£1100 per annum, according to the qualifications and experience of the successful candidate. Applicants should be Honours Graduates with a knowledge of advanced physical metallurgy, and an interest in X-ray metallography.

Applications, stating age, qualifications and experience, together with the names of three referees, should be received not later than 1st September, 1954, by the undersigned, from whom further particulars may be obtained.

STANLEY DUMBELL,
E9861 Registrar.

THE UNIVERSITY OF SHEFFIELD

LECTURER IN MECHANICAL ENGINEERING

Very considerable extensions in accommodation requirements to the Engineering Departments having been completed, applications are invited for Two posts of LECTURER IN MECHANICAL ENGINEERING, to begin duties on 1st October, 1954, or as soon as possible thereafter. Salary scale, £550 by £50 to £1100, with F.S.S.U. provision and family allowance. Initial salary on the scale according to qualifications and experience. Further particulars should be obtained from the Registrar, to whom applications (4 copies) should be sent by 30th August, 1954. E9809

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

ROAD RESEARCH LABORATORY

SCIENTIFIC OFFICERS

Department of Scientific and Industrial Research require unestablished SCIENTIFIC OFFICERS at Road Research Laboratory, Harmondsworth, Middx, and Langley, Bucks, as follows :—

(1) CLASSICAL PHYSICIST to undertake basic research on physics of soil moisture (Harmondsworth). Ref., A190/54A.

(2) CIVIL ENGINEER, to undertake research on the properties of bituminous road materials and related machinery problems (Harmondsworth). Ref., E467/54A.

(3) MATHEMATICIAN, STATISTICIAN or PHYSICIST, with experience in practical mathematics, for work on the analysis of accident statistics (Langley). Ref. A191/54A.

(4) CHEMIST, to undertake research into chemical (organic and inorganic) problems relating to soil foundations and to soil stabilisation processes (Harmondsworth). Ref., F485/54A.

Qualifications : First or Second-Class Honours Degree in an appropriate scientific subject, or equivalent qualifications. Inclusive annual remuneration at Harmondsworth for a 45½-hour week, £471–£860 (men), £471–£757 (women). Slightly less at Langley. Prospects of establishment for applicants under age 28.—Application forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting appropriate reference. Closing date 21st August, 1954. E9829

PUBLIC APPOINTMENTS

STAFFORDSHIRE POTTERIES WATER BOARD

APPOINTMENT OF CIVIL ENGINEERING ASSISTANT AND GRADUATE ASSISTANT

Applications are invited for the following appointments :—

(a) CIVIL ENGINEERING ASSISTANT, Grade A.P.T. II (£520 to £565 p.a.) Applicants must hold a University Degree in Civil Engineering and have at least one year's engineering experience, or have passed Part I of the Institution of Civil Engineers' Examination, and have at least two years' engineering experience.

(b) GRADUATE ASSISTANT, Grade A.P.T. I (£490 to £535 p.a.). Applicants must hold a University Degree in Civil Engineering. After one year's practical experience the salary will increase to Grade A.P.T. II (£520 to £565 p.a.), and after two years' practical experience Grade A.P.T. IV (£580 to £625 p.a.). Grade A.P.T. V (£620 to £670 p.a.) will be the salary scale for two years' practical experience and the passing of Parts I and II of the Institution of Civil Engineers' Examination.

The appointments are subject to the provisions of the National Scheme of Conditions of Service ; to the provisions of the Local Government Superannuation Act, 1937 ; to termination by one month's notice on either side, and to the successful candidates passing a medical examination.

The Board have considerable major works in hand, giving opportunities of preparing designs, specifications and supervising contracts for varied types of work.

Applications, stating age, full details of training, qualifications, present and previous appointments, details of experience, together with copies of two recent testimonials, or the names of two persons to whom reference can be made, should be forwarded to the undersigned not later than Monday, the 16th August, 1954.

C. V. BROWN,
M.I.C.E., M.I.Mech.E., M.I.W.E.,
Engineer and Manager
and Clerk.
Staffordshire Potteries Water Board,
Albion Street,
Hanley,
Stoke-on-Trent. E9767

ADMIRALTY

ROYAL NAVAL SCIENTIFIC SERVICE

SENIOR SCIENTIFIC OFFICER AND SCIENTIFIC OFFICER

SENIOR SCIENTIFIC OFFICER and SCIENTIFIC OFFICER required in Experimental Establishments in London, Portsmouth, Weymouth and Gloucestershire areas and Scotland. The majority of posts are for Engineers and Physicists (particularly with Electronics). Candidates must be British subjects with an appropriate First or Second Class Honours Degree or equivalent high professional attainments. Salaries : S.S.O. (M), £975–£1150 ; S.O. (M), £470–£855. London rates. Somewhat lower in Provinces. All appointments are unestablished (with F.S.S.U.) but with some opportunities to compete for established posts. Application forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting A246/52/A. E9226

STOKE-ON-TRENT HOSPITAL MANAGEMENT COMMITTEE

CITY GENERAL HOSPITAL, STOKE-ON-TRENT (900 BEDS)

ENGINEER-IN-CHARGE

ENGINEER-IN-CHARGE required. Applicants must have served an apprenticeship in mechanical engineering and have a sound knowledge of the principles and practice of the efficient operation of institutional boiler plants and engineering services generally, with some electrical knowledge.

Experience in control of staff is essential.

Salary, £585, rising to £685, subject to N.H.S. (superannuation) regulations.

Particulars of age, training and posts held with two references to be forwarded to the Secretary, City General Hospital, Stoke-on-Trent, by Saturday, 14th August, 1954. E9788

SOMERSET EDUCATION COMMITTEE

SCHOOL MEALS SERVICE

PLANT MAINTENANCE MECHANIC

PLANT MAINTENANCE MECHANIC required in Taunton. Salary £440 by £20 to £520 ; superannuable. Further particulars and application forms obtainable from the undersigned, to whom completed applications must be returned within 14 days.—W. J. Deacon, M.A., Chief Education Officer, Trull Road, Taunton. E9836

LONDON COUNTY COUNCIL

ENGINEERS AND ENGINEERING ASSISTANTS

Required, ENGINEERS and ENGINEERING ASSISTANTS. (a) For design and detailing of engineering structures in concrete and steel ; (b) for structural surveys and levelling of river walls and other flood prevention works within the County of London. Salaries within ranges £300–£556 ; £561–£739 ; £701–£892. Application form from Chief Engineer (54/38), London County Council, County Hall, S.E.1, returnable within next 14 days. (Enclose S.A.E.) (984). E9821

PUBLIC APPOINTMENTS

WEST MIDLANDS GAS BOARD

WALSALL AND DISTRICT DIVISION

DRAUGHTSMAN

Applications are invited for the position of DRAUGHTSMAN in the Divisional Distribution Engineering Department.

Candidates should have experience in the design of light steel structures and be capable of preparing general arrangements and detailed drawings of cast iron and mild steel pipe connections. Possession of the Higher National Certificate in Mechanical Engineering would be an advantage.

The salary for the post will be within Grade 7 (£565–£645 per annum) of the National Salary Scales for Gas Staffs.

The post is pensionable and the successful candidate may be required to pass a medical examination.

Applications, stating age, qualifications and experience, together with the names of two referees, should be addressed to Mr. E. Hardiker, Divisional General Manager, West Midlands Gas Board, Walsall and District Division, Walsall Factory Estate, Tame Bridge, West Bromwich Road, Walsall, to reach him within fifteen days of the appearance of this advertisement.

F. H. CURETON,
E9837 Secretary to the Board.

THE ATOMIC WEAPONS RESEARCH ESTABLISHMENT

ENGINEER (MAIN GRADE)

The Atomic Weapons Research Establishment, Aldermaston, Berks, requires an ENGINEER (Main Grade), to be responsible for a section engaged in the production of plans and specifications for all types of radioactive laboratories and workshops, with their ancillary buildings and services, and for the supervision to completion through building agents, of a large building programme. Applicants should have served a recognised engineering apprenticeship and be Corporate Members of one of the Institutions of Civil, Mechanical or Electrical Engineers, or have exempting qualifications. They should also have experience of ventilation and extract plants and effluent disposal systems. Experience in estimating or contractual procedure would be an advantage.

The salary range is £960, rising to £1240 per annum.

Houses available within a reasonable period for married staff who live outside the Establishment's transport facilities. Application form from Admin. Officer (Recruitment), A.W.R.E., Aldermaston, Berkshire. Quote Ref. 192/W.G.E./25. E9818

CITY OF LIVERPOOL

CITY ENGINEER AND SURVEYOR'S DEPARTMENT

ENGINEERING ASSISTANT

Applications are invited for the appointment of ENGINEERING ASSISTANT. Salary £550–£595 per annum (A.P.T. Grade III). Applicants should have passed the Intermediate Examination of the Institution of Municipal Engineers or hold an equivalent qualification. Preference will be given to candidates who have had experience in sewerage or sewage disposal works design.

Application forms, obtainable from the City Engineer and Surveyor, Municipal Buildings, Liverpool, 2, should be returned to him by the 20th August, 1954.

The appointment is superannuable and subject to the Standing Orders of the City Council. Canvassing disqualifies.

THOMAS ALKER,
Town Clerk.
Municipal Buildings,
Liverpool, 2 (JA3634)a. E9842

DEPARTMENT OF ATOMIC ENERGY

CHEMIST OR ENGINEER

CHEMIST or ENGINEER required by Department of Atomic Energy at Risley to assist in providing an advisory service, and in the scientific administration and co-ordination of a group of laboratories. Qualifications : either an Honours Degree in Science, or equivalent, or a recognised engineering apprenticeship with Corporate Membership of a Senior Engineering Institution ; varied engineering and scientific experience, with experience of staff management, costing and budgeting, and planning and progressing of work programmes, is desirable. Salary, £620 (age 25)–£960 ; superannuation scheme.—Application form from Department of Atomic Energy, Industrial Group Headquarters, Risley, Warrington, quoting 643. E9831

MINISTRY OF SUPPLY

ENGINEERS OR CHEMISTS

Ministry of Supply requires ENGINEERS or CHEMISTS at Chorley, Lancs, to supervise ammunition filling or develop new associated processes. Qualifications : British of British parents ; manufacturing or design experience essential, filling factory experience desirable. Engineers should have recognised engineering apprenticeship and A.M.I.C.E. or M.E. or E.E., or exempting qualifications ; Chemists, Hons. Degree in Chemistry or Chemical Engineering, or A.R.I.C. or A.M.I.Chem.E. or equivalent qualifications. Salary, £960–£1240. Not established, but opportunities to compete for establishment may arise.—Application forms from M.L.N.S., Technical and Scientific Register (K), Almack House, 26, King Street, London, S.W.1, quoting F497/54A. E9833

PUBLIC APPOINTMENTS

DEPARTMENT OF SCIENTIFIC INDUSTRIAL RESEARCH

ROAD RESEARCH LABORATO

EXPERIMENTAL OFFICERS, A ASSISTANT EXPERIMENTAL OFF

Department of Scientific and Industrial require EXPERIMENTAL OFFICER ASSISTANT EXPERIMENTAL OFFIC the Road Research Laboratory, Harmo Middx, and at Langley, Bucks, as follows :

(1) E.O.: Civil Engineer, with sound knowledge of mathematics for research on design of concrete roads. Practical exp civil engineering construction work an Ref. E432/54A.

(2) A.E.O.: Physicist for laboratory re flow of water in relation to drainage syste A192/54A.

(3) A.E.O.: Civil Engineer, for field inv on surface drainage. Ref., E468/54A.

(4) A.E.O.: Engineer or Physicist for re soil stabilisation. Ref., E469/54A.

(5) A.E.O.: Civil or Mechanical En Physicist for full-scale experiments with bi materials and for research on bitumino making machinery. Ref., E470/54A.

(6) A.E.O.: Physicist or Mechanical or E Engineer for work on vehicles. Ref., A193/

(7) A.E.O.: Physicist or Mechanical En work on road-user behaviour. Ref., A194/

Candidates for E.O. should be at leas have pass Degree, H.N.C. or equivalent in ap subject, and for A.E.O. be at least lit G.C.E. with two scientific subjects at advan or equivalent, and pass Degree, H.N.C. or e if over 22. Inclusive annual remunerati 45½-hour week within the following range to age and location :—E.O.: (Men) £ (Women) £612–£766 ; A.E.O.: (men) (women) £284–£346. Prospects of estab for candidates under 31 (E.O.) and 28 (A. Application forms from M.L.N.S., Techn Scientific Register (K), 26, King Street, S.W.1, quoting appropriate reference. Clo 28th August, 1954.

COUNTY OF CORNWAL

DEPUTY FERRY MANAGER

Applications are invited from qualified Engineers for the post of DEPUTY MA of the Torpoint Ferry, a steam ferry which between Torpoint and Devonport on th Tamar. The salary will be on a grade of £20 (2) by £25 (1) to £760. The post will b annuable and the usual service conditions Local Government Service will apply.

Applications, together with the names persons to whom reference may be made, be sent to me not later than 13th August, 19

E. T. VERGE
Clerk of the County Co

County Hall,
Truro,
July, 1954.

GOVERNMENT OF QATA

RESIDENT ENGINEER, WATER S

Applications are invited from Corporate M of the Institution of Civil Engineers for th appointment.

The duties consist of the supervision struction of a sea water distillation plant erection of overhead and ground level storage the laying of distribution pipework ; superv well drilling for underground water to augm distilled water ; the erection of pumping equ &c., in and around Doha.

The appointment is expected to last 18 mo Applicants should be between the ages of 30

The salary offered is in the range 2000 rupees per Arabic month. There is at pre income tax in Qatar.

Bachelor quarters only will be provided wife may be allowed to join her husband dur summer leave season.

Air passages on joining and termination, attention, light and water are provided free.

Applications to :—

J. D. and D. M. WATSON, M.M.I.C.
18, Queen Anne's Gate,
Westminster,
London,
S.W.1.

GOLD COAST LOCAL CIVIL SER

AGRICULTURAL DEPARTMENT

CIVIL ENGINEER

Duties : Administration of departmental including construction and maintenance of hu roads and drainage.

Appointment on contract/gratuity terms. in incremental scale £1130–£2020 per annu gratuity payable on satisfactory complet contract at rate of £37 10s. for each completed of three months' service.

Outfit allowance : Free first-class pas generous leave ; quarters at reasonable free medical attention.

Candidates must possess a University De diploma recognised as exempting from, o passed, the Final Parts I and II of the A.M examination and have at least two years' pr experience. Approved professional experie excess of the minimum will be considered in mining starting salary.

Full particulars on application to the Dire Recruitment, Colonial Office, Great Smith London, S.W.1. State briefly age, qualificatio experience, and quote ref. number BCD/63/ D4.

THE ENGINEER

JULY 30, 1954

Watford Derailment Inquiry Report

ON February 3rd last some coaches of the up "Royal Scot" were derailed in Watford tunnel, about 1½ miles north of Watford Junction in the London Midland Region of British Railways. The train, which consisted of ten bogie coaches, was travelling at about 65 m.p.h. through the mile-long tunnel when a rail broke under its passage and derailed the trailing wheels of the trailing bogie of the eighth coach. The train continued without further derailment for nearly 1½ miles but the derailed wheels then damaged points and crossings with the result that the ninth and tenth coaches were then derailed. They parted from the train but came to rest in an upright position. Just prior to their derailment, the speed of the train had been reduced by the pulling of the communication chain by a passenger in the ninth coach. Fortunately, there was no more than minor injury to fifteen of the passengers in the train. These facts are set out in the report of the inquiry which was conducted by Lieut.-Colonel G. R. S. Wilson of the Ministry of Transport. In the remarks and recommendations included in his report, Lieut.-Colonel Wilson says that, in recent years, over 1000 defective rails have been removed annually from the 36,500 miles of British Railways' running tracks, and rather more than one-third of the 1000 were actually broken. In all but rare cases defective rails are discovered and removed from the track before there is serious risk to traffic. The problem of rail breakages, Colonel Wilson comments, has always been more acute in steam worked tunnels owing to the rapid deterioration of the rails and fishplates in the corrosive atmosphere. Special attention has to be given to the periodical examination of the rail ends so that incipient defects may be discovered before they become dangerous. The fact that this was the first case of derailment from a broken rail in a tunnel for very many years illustrates the care which is generally exercised. In all the Regions, the report adds, portable ultrasonic detectors are now being used primarily for the inspection of rails in tunnels and other troublesome places to supplement the periodical visual examinations. Colonel Wilson also makes some comments about the communication chain. He says that the principle of using the continuous brake for passenger communication has stood the test of time on practically all the railways in the world, but he does not consider that the present arrangement in this country, at any rate with the vacuum brake, is sufficiently positive in its effect. He therefore recommends that the detailed design of the equipment on British Railways vacuum and air-braked passenger trains should be thoroughly reviewed so that it may be modified where necessary to obtain a quicker response to the pulling of a chain by a passenger.

World Power Conference, Rio de Janeiro

A SECTIONAL meeting of the World Power Conference is being held at Rio de Janeiro from July 25th to August 10th. It will be recalled that the World Power Conference was instituted in Great Britain in 1924, its purpose being to consider, by various means, "how the sources of heat and power may be adjusted nationally and internationally." After the 1924 meeting in London subsequent meetings of the conference were held in Berlin in 1930, in Washington in 1936, and again in London in 1950. Sectional meetings concerned with special interests of the conference have been held in Basel in 1926, London in 1928, Barcelona in 1929, Tokyo in 1929, Stockholm in 1933, London in 1936, Vienna in 1938, The Hague in 1947, and New Delhi in 1951. In the current sectional meeting in Rio de Janeiro the technical programme consists of a number of papers for discussion. The topics fall into the following seven groups :— Planning of the electrical power industry ; the electrical power industry in tropical and subtropical regions ; natural and derived fuels ; wind power ; solar energy ; uses of electric power, and international hydro-electric developments. Abstracts from one of the papers, "Integration of Hydro and Thermal Generation in Great Britain," by Messrs. J. D. Peattie and A. A. Fulton, are reproduced on page 158 of this issue. The programme of the Rio de Janeiro meeting includes a tour of places of technical interest, from August 2nd to 10th, and a number of social events have been arranged. Lord Citrine, chairman of the British Electricity Authority, is representing Her Majesty's Government as official delegate at the meeting, and Sir John Hacking is representing the British National Committee of the World Power Conference, of which he is vice-chairman. The United Kingdom delegation to the meeting numbers about thirty-one.

Proposed Bridge over the Mersey

AN investigation of the proposed Runcorn-Widnes suspension bridge over the River Mersey has recently been carried out by the National Physical Laboratory. A problem never previously considered in bridge engineering was encountered in this investigation, namely, buffeting of the suspension bridge, caused by disturbance of the air flow due to the nearby railway bridge. The laboratory has, after experiments in wind tunnels, been able to make suggestions which would reduce the buffeting to acceptable amounts. The proposed bridge is required to replace the old transporter bridge across the River Mersey and the Manchester Ship Canal, and has to have a clearance of 100ft above the canal. The consulting engineers are Messrs. Mott, Hay and Anderson. Oscillations of suspension bridges may be caused by wind in two ways ; they may be set up in steady winds because of the interaction of the bridge itself with the air stream (aerodynamic instability), or they may be due to disturbed air flow, which can cause buffeting. At Runcorn-Widnes the bridge has to be built near to the bridge carrying the main London-Liverpool railway line. It was found that powerful disturbances would be set up by this bridge and when the wind was in the west these disturbances would strike the proposed bridge. With the original design and site of the proposed suspension bridge, winds of 40 m.p.h. would have caused a rise and fall of about a foot in the bridge deck. Although this was not sufficient to endanger the bridge, it would have been highly objectionable to users, particularly to pedestrians. It was impracticable to redesign the railway bridge or to move the site of the suspension bridge sufficiently far away to be clear of the disturbances, so other means were sought. Tests showed that if the suspension bridge were built very close to the railway bridge, movement due to buffeting would be reduced. In addition, if the natural frequencies of the bridge were increased by making the structure more stiff, the objectionable buffetings would not be reached until wind speeds were considerably higher. The N.P.L. recommended that the suspension bridge should be built as close as possible to the railway bridge and that the bridge should have deeper stiffening trusses and overhead horizontal bracing. The smallest practicable distance apart was 60ft and for the stiffened bridge in this position the buffeting would be reduced to about half in a wind of 50 m.p.h. Winds of this speed occur very infrequently. The recommendations increased the cost of the proposed suspension bridge, bringing it near to the cost of other kinds of construction. The deeper stiffening trusses and overhead bracing caused the bridge to be less pleasing æsthetically, but, the N.P.L. considers, in an area so starkly functional this may not be a matter of much importance. We understand that the bridge committee has now decided to build a steel arch bridge instead of the suspension design.

Standards and Exports

THE British Standards Institution has formed an export panel of industrialists to tender advice as to how the B.S.I. can best assist the export trade. It says that the volume and range of overseas work connected with standards have greatly increased in recent years, and that the development of national standards in overseas countries has a direct bearing on British manufacturers' export activities. It is therefore essential, the B.S.I. asserts, that British industry should take a leading part in influencing developments in the international standards field. To enable manufacturers to take account of other countries' standards in their production for export, the British Standards Institution provides British industry with a complete information service about overseas standards. It believes it to be equally necessary that in formulating British standards full account should be taken of the requirements of export markets. The proper execution of this service to British industry, it is considered, calls for the best guidance which the exporting industries can offer to the B.S.I. One practical task of the new panel will be to suggest ways in which the use of British standards overseas can be promoted, and how the availability of British standards in all parts of the world can be improved. Mr. J. L. S. Steel, of Imperial Chemical Industries, Ltd., will act as chairman of the panel, the other members at present appointed being Mr. G. H. Andrew, Board of Trade ; Mr. D. Maxwell Buist, BEAMA ; Mr. Leslie Gamage, president of the Institute of Export ; Sir Ernest Goodale, president of the Silk and Rayon Users' Association ; Mr. Hector McNeill and Mr. J. W. Ridgeway, who were nominated by the Federation of British Industries, and Mr. R. L. Wills, who represents the National General Export Merchants Group and the London Chamber of Commerce.

Duty-Free Machinery

A COMMITTEE was set up by the President of the Board of Trade in March of last year to consider whether it was in the national interest to provide for the duty-free admission into the United Kingdom of machinery, either by classes or in individual consignments. The committee's task also included a review of the provisions of Section 10 of the Finance Act, 1932, and the making of recommendations as to whether any changes should be made. The report of the committee has now been published. The committee agrees that some discretionary system to permit the duty-free entry of machinery in suitable cases is in the national interest, and considers that the provisions should continue to be operated by Government departments. It is recommended that the duty-free entry of machinery should be by consignments and that the field for applications should not be limited to specified classes of machinery. The report goes on to say that the basic criterion for duty-free admission should be the "non-procurability" of similar machines in the United Kingdom. It adds that the suitability of machines for the particular work for which they are required should be taken into account when applying the test of similarity, provided that the applicant can establish that the machine is to be used to a very substantial extent for this special purpose. Another recommendation is that duty-free entry provisions should be extended to plant, but the committee says that applications should be scrutinised very closely and that import duty should be remitted only on those constituents of plant that are not procurable in the United Kingdom. Sir Henry Wilson Smith served as chairman of the committee.

Some Notes on the Development of Fairground Machinery

By P. W. BRADLEY

No. III—(*Continued from page* 112, *July* 23*rd*)

In this article the author continues to trace the evolution of the ordinary roundabout, with particular reference to the development of a satisfactory galloping action for the wooden horses. It is confined to those machines in which a fixed axis supports the whole revolving mass.

IT has been seen that Frederick Savage did not figure in connection with the earliest overhead-crank "gallopers" arrangements; although he devised a "galloping horses" circular ride of rather different style. He, at the time, was doubtless preoccupied with the switchback type of ride, for by 1888 he had developed this virtually to finality. Knowing of his insistence on basically simple design and sound engineering practice, we can only guess at his opinion of the combinations of cranks and levers which the "overhead cranks" pioneers specified; and when, in 1891, he patented a "platform slide" for overhead crankshaft roundabouts he finalised the mechanical design of that class of machine as well.

The idea was so simple that it is remarkable that it was not thought of earlier. To a machine with a single set of radial crankshafts, he fitted horses mounted on rods depending from the crankpin bearings, as did Tidmans. But the rods continued downward, below the horses, to pass through radial slots in the platform. Hence the lower ends of the rods were restrained longitudinally, but were permitted lateral movement as the speed of the machine changed. The lower ends of the three (or four) rods in a set passed through holes in a metal strip, arranged to slide in guides. This, whilst not restricting lateral movement between fixed limits, ensured that the horses of a set remained at uniform spacing. At first the slides were fitted above the platform and suitably encased; but shortly afterwards they were sunken, so as to give a flush surface. The platform slide quickly became very popular and for forty or more years practically all overhead crank machines have had this arrangement.

Of the three principal roundabout building concerns of the period, it has been seen that two (Frederick Savage and Messrs. Tidman) made positive contributions towards "gallopers" development. The third, Walkers of Tewkesbury, do not figure in Patent Office records until 1893. In that year, Mr. Thomas Walker patented a device whereby galloping horses derived their motion from an annular cam fixed to the centre pole, where it replaced the normal bevel wheel; but as the arrangement involved the three horses of a set rising and falling in unison, it is hardly surprising that nothing more was heard of the idea. In 1908 Messrs. Thomas and J. R. Walker patented another arrangement involving an annular cam, in this case used to impart partial rotary motion to a series of radial crankshafts; but no evidence has come to light to establish that the system was ever used. Invention of mechanisms does not seem to have been Messrs. Walker's bent; but their products built to others' specifications were of splendid design and workmanship, as anyone who inspected the Walker-built galloping horses at the Lower Hampstead Heath bank holiday fairs in 1952 will testify.

After Savage's invention of the platform slide, there were no further basic changes in "gallopers" design. Many sets were built, mostly by Savages, Walkers and Tidmans, between 1891 and 1926, but developments during this period were only in matters of detail. Sizes naturally varied, but the vast majority could be classed as small three abreast, large three abreast, small four abreast, or large four abreast. The first type had thirty-six single-seater horses and was about 36ft in diameter. Little larger than a good-sized "dobby horse" machine, it was intended for village fairs and fêtes. The larger three abreast also had thirty-six horses, but some or all were double-seaters, and the diameter 40ft to 42ft. This was a useful size for the showman with an average run of fairs, and was built in large numbers. The machine which has spent the last three summers in Battersea Park belongs to this class, and incidentally is believed to be the last complete set built by Savages. Thirdly, there was the smaller four abreast set; still in twelve sections and having, therefore, forty-eight horses; the diameter being about 45ft. Comparatively few of this class were built, although one specimen was a feature of the Lower Hampstead Heath holiday fairs for many

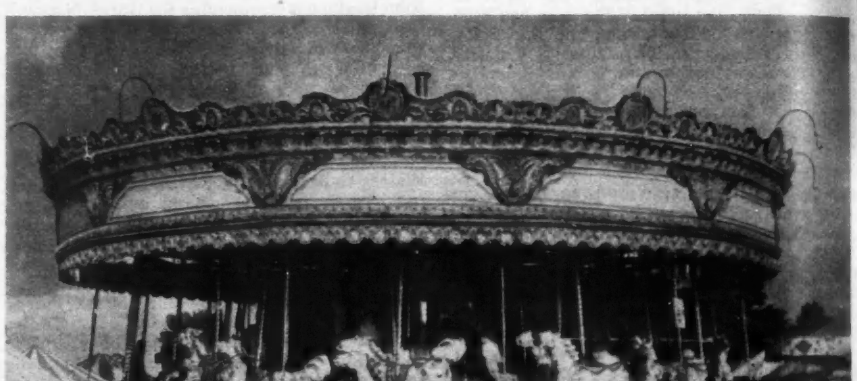


Fig. 6—Example of a Savage three-abreast "Galloping Horses" machine with twenty-four double-seater "Horses" and twelve single-seater "Birds." It is about 42ft in diameter

Fig. 7—Savage-built centre truck of three-abreast "Gallopers" ready for hauling on to its gantry, with the "pole" top lowered for travelling

years until its sale to a coastal amusement park eight or nine years ago. Lastly, for the showman with a first-class run of important fairs, all three firms produced a fourteen section four-abreast with a diameter of 48ft, and if fitted with double-seaters throughout, a capacity of 112 adults. Several of these very large sets were built and they

Fig. 8—Savage centre engine of twin cylinder "simple" design, with "in-between" valves. The separate organ engine and the inclined eccentric-driven boiler feed pump can be seen

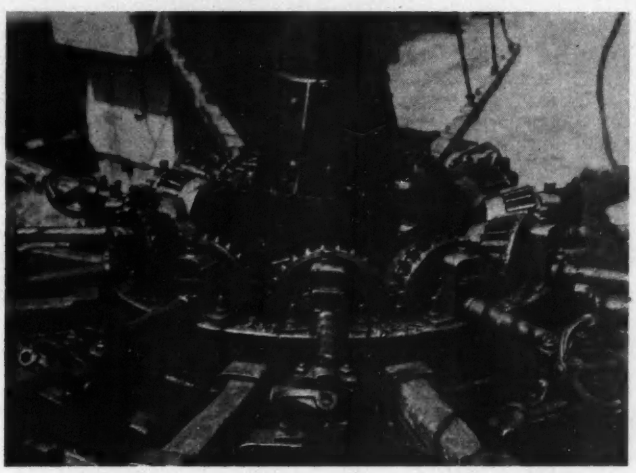


Fig. 9—The top gearing of the Savage three-abreast "Galloping Horses." The twelve bevel pinions on the radial shafts have "plain-face" inner extensions running on an appropriate race

were popular at one time in South Wales, the Black Country, South-East Lancashire and other industrial areas.

We may now consider in more detail the design of a thirty-six-horse, three-abreast set, as being numerically the most popular. The five illustrations depict examples of that class, as built by Savages. Fig. 6 shows a machine fully erected and Fig. 7 a centre truck. Figs. 8 and 9 are details of the steam engine and the top gearing. Before the revolving structure is built the centre truck is hauled up a ramp onto a gantry about 18in high, and the road springs are then relieved by five jacks mounted on tall bases, to support the "centre pole" and its four struts. The longitudinal jacking plank seen in Fig. 7 is a permanency, as is the rear strut; but the transverse jacking plank and the lower portions of the side and front struts are of necessity removable, to enable the steering forecarriage to turn. The engine is fitted in a depression at the rear and, as seen in Fig. 8, is of two-cylinder "simple" pattern with "in-between" valves. Walker engines were very similar, but Tidmans always favoured outside valve chests.

The drive is taken via spur reduction gearing to a short shaft at about deck level, and thence through equal bevel gears to a vertical shaft within the ornamental "drum." A pinion at the head of this shaft drives internally a bar-toothed gear under the cheesewheel. A friction brake operates on the engine flywheel, and the primary reduction gearing can be disengaged. A small vertical organ engine is carried on the smokebox and drives by a flat belt the countershaft clearly shown in Fig. 7. From this shaft a second flat belt takes the drive to the bellows crankshaft of the organ, which is permanently mounted on its own four-wheeled truck. The ornamental spinning pillars surrounding the "drum" (seen in Fig. 7) were usually fitted to older Savage centres, but the writer has never seen a set in operation. Each has a chain wheel at its foot; but just how the drive was imparted is not known. The ring surrounding the drum and supported on light uprights is for the lighting installation; wipers on the revolving portion engage its upper surface. The hinged extension of the "centre pole" is shown lowered in Fig. 7 and raised in Fig. 9; it is, of course, hollow. A flue runs horizontally from the smokebox base, over the rear axle of the truck and into the "pole"; in Walker examples it was generally inclined upwards inside the drum. At the base of the pole, just above the jacking plank, is an access trap for de-sooting operations.

The "top motion" photograph, Fig. 9, for which the writer is much indebted to Mr. F. C. L. Stokes, shows the inner ends of the swifts alternating with the twelve driving shafts, each carried in one plain and one sprung bearing. These and the "plain face" portion of the bevel wheels, ensure constant and correct mesh. Almost the whole weight of the revolving structure is taken by the top race via three rods per swift, some of which are just visible in the background of the illustration; for in single crank gallopers it was not the practice to transmit the weight to the main bearing and crankshaft gearing, as did Reynolds and King. The crankshafts in a machine of the kind under consideration are journalled in bearings on the quarterings (either three or four per crankshaft, depending on whether or not the outermost cranks are overhung; they are on most early and some later sets) and carry on their inner ends ring universal couplings similar to those shown in Fig. 9. The drive is taken from coupling to coupling via short cardan shafts. The platform calls for little comment; as shown in Fig. 6, it and the steps are segmental, with staggered joints. Each platform slide falls in the centre of a platform section. Sets of diagonal rods, with strainers, are fitted between platform and top frame (one appears in the foreground of Fig. 8) to prevent platform sway, and within the top frame, to distribute braking and starting torque. In a modern three-abreast machine of the kind under review, the cranks in each crankshaft are set at 60 deg., the running speed is about eight circuits per minute, and the crankshafts make about three-and-three-quarter revolutions per circuit.

In Fig. 10 is shown a Savage three-abreast set, complete, excepting organ, ready for the road. The road locomotive, in this case of Burrell manufacture, is a standard showman's machine, for galloping horses duties do not require special attachments of any kind. Next to the centre truck is a 22ft vehicle with open-framed body, on

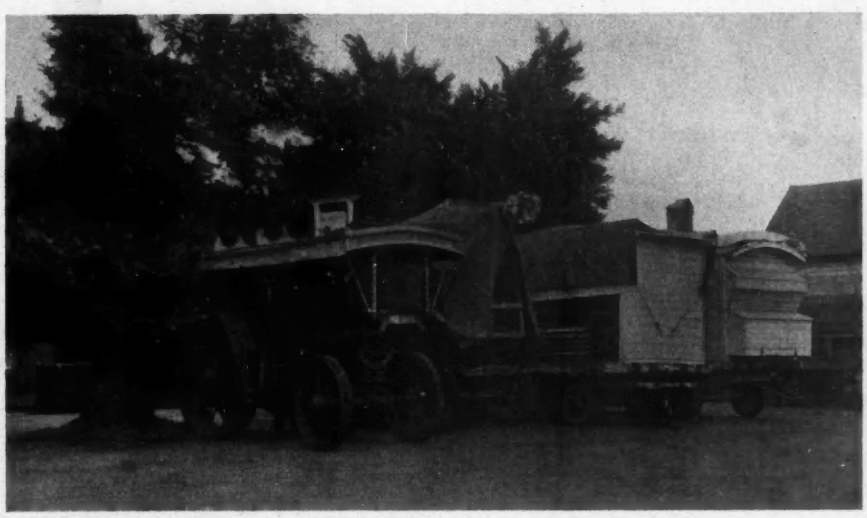


Fig. 10—Savage three-abreast "Galloping Horses," and accompanying Burrell engine "Lord Fisher." This is one of the very few sets still steam-driven

the floor of which are carried the platforms in two stacks of six, with the twenty-four steps sections stacked on them. In the upper portion of the vehicle, removable crossbars carry the swifts, quarterings, crankshafts, cardan shafts, rods and "rounding boards," and the overall height is such that the truck can stand close to the centre (when on its gantry) and just clear the swifts. Two men standing in the top of the truck can build the top remarkably quickly. The truck with van body, slightly shorter, carries the thirty-six horses on end, in rows six abreast, the protrusion on the front accommodating the heads of the first row. Lower down is a box for lamps and sundries. The decorative centre screens and other fittings are also packed in this vehicle.

At one period Tidmans of Norwich produced an alternative design of galloper's centre, wherein the engine was arranged longitudinally in the truck, in a well formed in the frame, rather than across one end. The arrangement was tried in both three-abreast and four-abreast sets of this firm's manufacture, and certainly rendered the engine more accessible. The only machine of this kind of which the writer had close knowledge was prone to platform swaying and this was a constant source of anxiety. Conventional centres are surprisingly free of movement and hence undesirable platform oscillation. Generally, two stiff legs, slightly inclined, support the rear (engine) end of the centre truck and these are braced by crossed chains incorporating strainers. This arrangement is amply sufficient, provided regulator and brake are handled sensibly.

Galloping horses machines built with other than steam drive were few; in fact, the writer has heard of only four which were electric at the outset. Conversion to electric drive, unusual before 1939, became popular during and since the war, and few steam sets now survive. In some instances, the electric motor is accommodated in the space formerly occupied by the feed tank, so that for appearance's sake, the engine can be retained. Harmless deception of this kind is nothing new; for when Messrs. Savage and Walker fitted the organ vertical engine on the truck floor, as in some designs they did, they fitted a handsome brass chimney to the smokebox. Actually, of course, the outlet was via the usual horizontal or inclined flue to the centre pole.

Little need be said about the operation of these machines. Even loading is obviously desirable, and to this end the machine is kept moving slowly between rides. At all times when erected but not operating, packing is inserted between the ground and the lower step at several points, to relieve the structure to some extent. Siting does not present difficulties; "middle ground" is desirable but by no means essential; but a reasonably level site is almost a necessity, otherwise fixed supplementary steps have to be erected at low points, and these can be a source of accidents. The decorative aspect of fairground equipment does not fall within the scope of these notes, but the subject has been ably treated by Miss Barbara Jones in a chapter of her recent book, "The Unsophisticated Arts." Special attention is given to galloping horses machines, and there are several excellent illustrations of typical horses and birds seen on these roundabouts.

For many years the galloping horses were by far the commonest English fairground ride, and many small fairs had no other power-driven device. The machine suffered a decline in the later 'thirties, but seemed to recover during the war. Nowadays the surviving examples are rather unevenly distributed over the country; the London and Home Counties area being more fortunate than most districts in having several very well-preserved examples, including (at the time of writing) one still steam-driven. To the best of the author's knowledge, no new set has been built in this country since about 1926, and many of the surviving sets are certainly fifty years old or more.

(To be continued)

Determination of Economic Steam Cycle for Nuclear Power Stations

By P. H. MARGEN, B.Sc.(Eng.), A.M.I.E.E.*

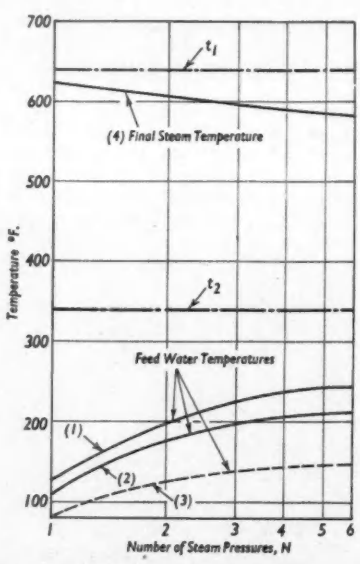
No. II—(*Concluded from page 115, July 23rd*)

In combustion steam stations there has been a trend towards the adoption of single-stage reheating cycles and even two-stage reheating is being considered for a few stations.[1, 2] These developments reflect the endeavour to select the highest cycle efficiencies obtainable with the steels now available. In contrast, most of the nuclear power station projects mentioned in the literature[3, 4, 5] have moderate steam temperatures, are not provided with reheaters and, in at least one case, make use of a steam cycle employing two steam pressures.[3] The present article examines the reasons for this trend of development of the nuclear station steam cycle and discusses how the optimum cycle can be found for any particular conditions. Certain parts of this subject have been discussed briefly in references [6] and [7], but no comprehensive treatment has been published.

Economic Feed Water and Superheat Temperatures

CURVE (1) on Fig. 7 shows the feed temperatures giving the highest distribution factor plotted against the number of steam pressures for given values of t_1, t_2, D_h and T_r. With an infinite number of bled steam feed-heating stages these feed heating temperatures also give the highest cycle efficiencies within the limits of accuracy of an approximation explained in Appendix 3.

For a finite number of bled steam feed heaters the highest cycle efficiencies are obtained with somewhat lower feed temperatures, as shown by curve (2), which is drawn for the case of two heaters. The economic feed temperatures are lower still, because a reduction in the feed water temperature reduces the cost of the feed heaters without reducing the cycle efficiency by appreciable amounts. The estimated economic feed temperatures are indicated by the broken line, curve (3). These temperatures are well below the feed water temperatures for combustion steam stations, and indeed do not provide for any feed heating at all for single-pressure cycles. Designs 2 and 6 on Table I *ante* conform with this conclusion. For two or three pressure cycles one bled steam feed heater can be justified.



(1) and (4) are the temperatures for maximum F_1.
(2) Feed temperatures for highest cycle efficiency with two bled steam feed heaters.
(3) Estimated economic feed temperature.

Fig. 7—Optimum feed water and steam temperatures

Fig. 7 applies only for the stated values of t_1, t_2, D_h and T_r. As mentioned by Robbins,[7] a reduction in the reactor coolant temperature range $(t_1 - t_2)$ tends to increase the economic feed water temperatures.

Curve (4) on Fig. 7 shows the superheater temperatures giving the highest distribution factor for given values of t_1, t_2, D_h and T_r. The economic temperatures would be slightly below the values given by this curve because the heat transfer coefficients for the superheater are lower than those for the boiler and preheater, so that it is more expensive to add heat to the working fluid in the superheater than in the boiler or preheater.

Combined Nuclear and Combustion Stations

The heavy capital cost of nuclear power stations will probably prevent a complete change-over from combustion to nuclear plant construction within the foreseeable future, though nuclear stations may well form an ever-increasing fraction of the annual plant construction programme.

From the aspect of thermodynamics the simultaneous construction of nuclear and combustion plants would be most effective if the two kinds of plant were integrated in a combined station, in which the nuclear part supplied the low-grade heat requirements and the combustion part the high-grade heat.

One form of such a combined plant consists of an ordinary nuclear station with the addition of a combustion superheater. This superheater might heat the steam from 605 deg. to 1050 deg. Fah. and would thus take in heat at a very high mean temperature, being equivalent, thermodynamically, to a combustion station operating on an extremely advanced heat cycle. Moreover, the superheater would dry the steam, thereby improving the blading efficiency in the low-

* Messrs. Kennedy and Donkin.

pressure turbine stages. If the combined station were designed for an electrical output of 570MW it would consume the same quantities of nuclear fuel as a 400MW nuclear station with a final steam temperature of 605 deg. Fah., and the same quantities of combustion fuel as a 145MW combustion station with 1500 p.s.i.g. 1050 deg. Fah. steam, reheated to 1050 deg. Fah. It would thus achieve a net gain of 25MW electrical output compared with the separate stations.

Fig. 8 shows the circuit for another kind of

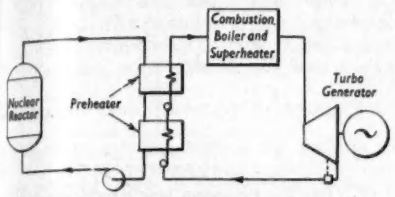


Fig. 8—Circuit for combustion station with nuclear preheater

combined plant in which the nuclear reactor and heat exchanger supply the preheat, and a combustion plant supplies the latent and superheat. The full lines on Fig. 9 show the steam cycle for this arrangement, whilst the broken lines show, for comparison purposes, the steam cycles for separate nuclear and combustion stations designed for similar heat quantities and limiting temperatures. Since the heat intake curve BCD for the combined scheme is, at most points, above the heat intake curves BC_1 and C_2D for the separate stations, the combined scheme has a higher ideal efficiency. Moreover, it minimises the extent of the bled steam feed heating system, thereby reducing capital cost, pumping power and irreversible heat transfer processes, and it achieves a relatively uniform temperature difference across the heat exchanger without recourse to the multi-pressure, preheater, boiler and superheater arrangements for the separate nuclear station.

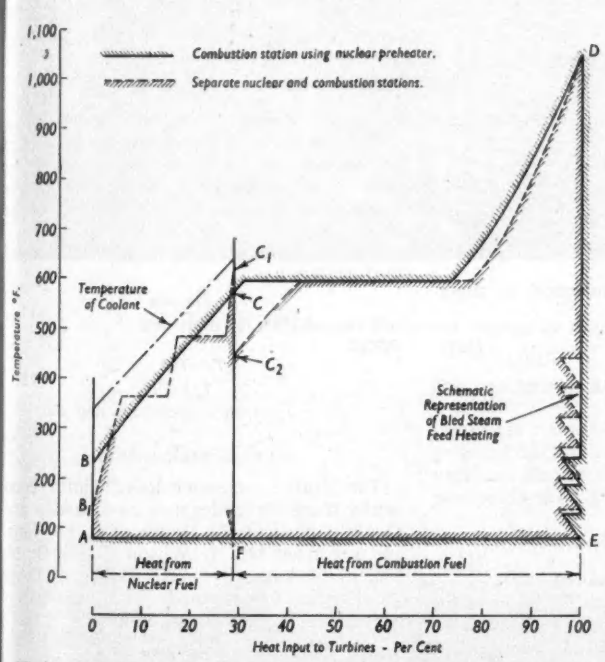

Combustion station using nuclear preheater.
Separate nuclear and combustion stations.
Temperature °F.
Temperature of Coolant
Schematic Representation of Bled Steam Feed Heating
Heat from Nuclear Fuel
Heat from Combustion Fuel
Heat Input to Turbines - Per Cent

Fig. 9—Cycle for combustion station using nuclear preheater, compared with cycles for separate nuclear and combustion stations

Table III shows that a combined station of this kind with an electrical output of 551MW consumes the same quantity of nuclear fuel as a 100MW output nuclear station, and the same quantity of combustion fuel as a 428MW output combustion station, thereby realising a net gain in output of 23MW. This increase in output increases the financial value of the nuclear reactor and heat exchange by 23 per cent, and there is a further increase in value arising from estimated reductions in the capital cost of the combined plant relative to the capital cost of the separate stations.

If large reactors are used in combined stations of this kind, then a single reactor could heat the feed water for several turbo-generators, using one preheater per turbine. One by-pass with a bled steam heater across each nuclear preheater would preserve continuity of supply during reactor shutdowns.

A further simplification would result from the use of a water-cooled reactor directly as preheater. This would save the capital cost of the heat exchanger and avoid the temperature difference between the coolant and the feed water. The reactor should present design problems no greater than those for the 2000 p.s.i.g. water-cooled reactor in the recently published United States Atomic Energy Commission reactor programme[5].

The above discussion of the merits of combined nuclear and combustion plant ignores possible objections such as the extension of health precautions to a larger operating staff. If objections of this nature can be overcome, then combined schemes offer substantial advantages and may well form an important stage in the transition from combustion stations to nuclear plant.

Table III—*Comparison of Combined and Separate Nuclear and Combustion Stations*

Item	Combined plant			Separate stations	
	Nuclear part	Combustion part	Total	Nuclear station	Combustion station
1. Cycle on Fig. 9	ABCF	FCDE	ABCDEF	AB_1C_1F	FC_2DE
2. Temperature of working fluid :					
(*a*) Entering heat exchanger, deg. Fah.	236	576	236	135	440*
(*b*) Leaving heat exchanger, deg. Fah.	584	1050	1050	605	1050
3. Nominal working fluid pressure, p.s.i.g.	1500	1500	1500	150/575	1500
4. Number of bled steam feed heating stages (*n*)	∞	3	3	1	6
5. Heat released by fuel, MW	438	1250	1688	438	1250
6. Heat input to coolant from fans, MW	27	—	27	27	—
7. Total heat input to working fluid=(5)+(6), MW	465	1250	1715	465	1250
8. Efficiency of heat exchanger and ducting	0·96	0·88	—	0·96	0·88
9. Heat to turbine=(7)×(8), MW	447	1100	1547	447	1100
10. Cycle efficiencies with :					
(*a*) Infinite stage feed heating	0·382†	0·519	0·479	0·365†	0·508
(*b*) *n* stages of feed heating ‡	0·382	0·515	0·476	0·364	0·500
11. Turbo-generator efficiency ratio	0·820	0·820	0·820	0·816§	0·820
12. Turbo-generator output=(9)×(106)×(11), MW	140	465	605	132·5	551
13. Coolant circulating power, MW	27	—	27	27	—
14. Consumption of other auxiliaries, MW	4	23	26	5·5	23
15. Net electrical output=(12)−(13)−(14), MW	109	442	551	100	428
16. Additional output with combined scheme, MW			551−528=23MW		
17. Overall thermal efficiency=(16)/(5)	0·249	0·354	0·327	0·228	0·343

* This temperature may be compared with the values 410 deg. and 453 deg. Fah. cited for two 1500 p.s.i.g., 1050 deg. Fah turbines in reference [4].
† Based on T_1=640 deg. Fah., T_4=340 deg. Fah., D_A=75 deg. Fah.
‡ Calculated from equation (17) in Appendix 3.
§ Reduced from value 0·820 to allow for higher wetness of steam in low-pressure turbine stages.

Conclusions

The points emerging from the discussion in this article may be summarised as follows :

(1) Because the fuel costs in nuclear power stations are relatively low, the emphasis in the design is not on the attainment of high thermal efficiencies as such, but on the attainment of high values of the product : (thermal efficiency)×(heat rating of fuel), i.e., the electric power output per unit mass of fuel for a given kind of reactor.

(2) This aim is achieved when the mean temperature of heat intake by the working fluid, T_i, is slightly below the midpoint between :

(i) The maximum permissible temperature of the fuel element or coolant ;

(ii) The vacuum temperature in the condenser.

With current design techniques this appears to give, for example, $T_i \simeq 400$ deg. Fah. with CO_2-cooled natural uranium reactors, and $T_i \simeq 530$ deg. Fah. with sodium-cooled fast reactors.

(3) There are several exceptions to conclusions (1) and (2), in particular the case where shortage of plutonium inflates the financial value of the fuel elements withdrawn from the pile. In these circumstances rather lower values of T_i tend to be economic.

(4) The type of steam cycle is chosen with the aim of producing a relatively uniform temperature difference between the coolant and the working fluid. This is achieved by employing several steam pressures and a low feed water temperature. The best overall economy would usually be obtained by using two or three steam pressures and one bled steam feed heater.

(5) Three turbine arrangements have been described. Arrangement "C," comprising one condensing turbine with two steam inlet points and one reheater (when applied to a two-pressure cycle) is the most efficient arrangement, but detailed cost comparisons would have to be made for each particular piping layout to ascertain whether or not it was also the most economic arrangement.

(6) Nuclear and combustion plant is likely to be constructed simultaneously in Britain for many years. If this plant were housed in combined stations in which the nuclear part supplied the low-grade heat and the combustion part the high-grade heat, then important thermodynamic advantages would be realised relative to separate nuclear and combustion stations. Provided practical objections, such as the exposure of additional staff to health precautions, can be met, such combined schemes may form an important stage in the transition from combustion to nuclear power generation. Combined stations using water-cooled reactors directly as preheaters appear particularly attractive at the present stage of development.

While the engineering and economic principles on which the foregoing analysis was

based are fundamental, the published data used for the numerical calculations are meagre. It is, however, unlikely that re-examination in the light of data at present unavailable would seriously modify the conclusions.

Appendices

(1) *Determination of R.*

Introducing the constants $b=(\theta_M-T_r)$ and $c=(\theta_M+460)$, equation (1) in the text may be rewritten in the form

$$p=q\eta_r\left[\frac{b-q/a}{c-q/a}\right] \quad . \quad . \quad . \quad (5)$$

To find the condition which will make p a maximum, equation (5) may be differentiated with respect to q and equated to zero. This gives

$$(b-q/a)=Rb \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

where

$$R=1-\frac{c}{b}\left[1-\sqrt{1-b/c}\right] \quad . \quad . \quad (7)$$

Equation (6) is identical with equation (2) in the text, and equation (7) defines the value of R for maximum generator output. Expanding (7) and neglecting small terms, the approximation $R\simeq\frac{1}{2}$ is obtained. If the small terms are not neglected, $T_r=80$ deg. Fah., and $500<\theta_M<1100$ deg. Fah., then $0{\cdot}37<R<0{\cdot}43$. Hence one may write $R\simeq0{\cdot}4$.

To obtain the value of R for minimum cost of electricity, let :

C_F=Net cost of fuel per MW-year of heat released ;

C_T=Annual capital charges and operating costs on turbo-generators and associated works per MW of generator capacity ;

C_R=Annual capital charges and operating costs for reactor, heat exchanger, coolant, fan or pump, and associated works, expressed per MW of heat released for one degree heat transfer temperature difference ;

L=Annual load factor, per unit.

The cost of electricity per MW-year generated then amounts to

$$Z=\frac{C_T}{L}+\frac{C_R}{\eta_r L}\left[\frac{a}{q}+e\right]\left[\frac{c-q/a}{b-q/a}\right] \quad . \quad (8)$$

This is a minimum when equation (6) is satisfied and R has the value

$$R=1-\frac{c}{b}\left[\frac{1-\sqrt{1-[1-e(c-b)]b/c}}{[1-e(c-b)]}\right] . \quad (9)$$

This equation reduces to equation (7) when $e=0$, i.e. when the net fuel cost is negligible compared with the capital charges and operation costs.

Sir John Cockcroft[8] indicated that natural uranium fuel elements might cost between £5000 and £15,000 per ton and that 0·333 to 1·0 of the potential heat of fission in the U235 (amounting to 2500MW-years per ton of U235, or about 18MW-years per ton of natural uranium) might be extracted before the fuel elements are withdrawn. Using the intermediate values £11,000 and 0·5, and neglecting interest payments, the cost of the fuel elements would amount to £1220 per MW-year of heat liberated. Some 30 per cent of this might be offset by the financial value of the depleted fuel elements which can be used for further power production in fast and slow reactors after reprocessing, leaving a net cost of £860 per MW-year of heat.

Table IV shows some data extracted from reference [4] to assess the value of the cost factor C_R. The figures for different designs vary over a wide range, and since the estimates were prepared as early as 1952, they can only give an indication of the order of magnitude of C_R. Taking the intermediate value, C_R=£800,000 (deg. Fah.)/(MW of heat) (annum) for the sake of this example, and assuming a load factor of 0·8, one obtains $e=0{\cdot}00086$.

For $\theta=800$ deg. Fah. and $T_r=80$ deg. Fah., we have $b=720$ deg. Fah. and $c=1260$ deg. Fah. With these values equation (9) gives $R=0{\cdot}45$. This deviates only by 0·05 from the general value obtained for $e=0$.

Equation (9) neglects the influence of T_i on the cost of the heat exchanger, on the one hand, and condensers and cooling towers on the other. As mentioned in the text, these two influences, however, tend to cancel. The equation is based on the electricity generated, whereas strictly the energy sent out should be used. Since, however, the power consumption of the largest auxiliary, namely the coolant fan or pump, is maintained constant throughout the comparison, a correction for the auxiliary power does not materially affect the result.

Table IV—*Nuclear Station Cost Data*[4]

Item	Design Number (from Table I)			
	2	5	6	7
1. Total capital cost,* 10^6 £...	14·3	14·7	42·2	18·2
2. Operating costs, 10^6 £/annum	(0·20)	0·56	(2·0)†	0·54
3. Capital charges at 10 per cent £/annum	1·43	1·47	4·22	1·82
4. Capital charges plus operation, 10^6 £/annum	1·63	2·03	6·22	2·36
5. Component of (4) attributed to reactor, heat exchanger, coolant fans, &c., 10^6 £/annum	1·00	1·33	4·40	1·87
6. Heat quantity released, MW	350	500	1064	500
7. Temperature difference, (θ_M-T_r), deg. Fah.	635	427	67	224
8. C_R=(5) × (7)/(6), 10^6£, deg. Fah./MW annum	1·82	1·04	0·28	0·85

* Costs in items 1 and 2 are converted from data in reference [4] at dollars 2·8=£1·0. Costs in brackets are estimated by author. 10 per cent capital charge rate is arbitrary assumption by author.

† Relatively high value taken to allow for cost of D_2O make-up.

(2) *Formulæ for Distribution Factor.*

The heat transfer diagram for all steam cycles can be reduced to the equivalent diagram shown on Fig. 10, which has a harmonic mean temperature difference,

$$D_h=\Delta/log_e\left[\frac{D_m+\Delta}{D_m-\Delta}\right] \quad . \quad . \quad (10)$$

where

$$\Delta=\frac{t_1-t_2}{N} \quad . \quad . \quad . \quad . \quad . \quad (11)$$

with a cycle having no preheaters or superheater and

$$\Delta=\frac{t_1-t_2}{N[1+0{\cdot}8(t_1-t_2+\Delta)/L_s]} \quad . \quad (12)$$

with a cycle having both preheaters and superheaters.

In expression (12) the factor 0·8 represents half the sum of the mean specific heats of steam and water, and L_s represents the mean value of latent heat of steam. The expression leads to the quadratic

$$0{\cdot}8\Delta^2+[L_s+0{\cdot}8(t_1-t_2)]\Delta-L_s(t_1-t_2)/N=0 \quad . \quad . \quad . \quad (13)$$

from which Δ can be calculated.

From equation (10) the distribution factor $F_d=D_h/D_m$ can be calculated for any value of the ratio Δ/D_m and plotted against D_h/Δ (which amounts to $ND_h/(t_1-t_2)$ when there is no preheater or superheater). The curves on Fig. 5 are drawn for L_s=800 B.Th.U. per pound.

(3) *Ideal Cycle Efficiency.*

To obtain the ideal cycle efficiency for infinite stage regenerative feed heating from the term $(T_i-T_r)/(T_i+460)$ in equation (1), one may calculate T_i with the aid of steam tables from the expression

$$(T_i+460)=(H-h)/(\Theta-\phi) \quad . \quad . \quad (14)$$

where H and Θ are respectively the enthalpy and entropy of the steam entering the turbine, and h and ϕ are respectively the enthalpy and entropy of the heat exchanger feed water.

In the case of multi-pressure cycles evaluation of this expression is laborious and

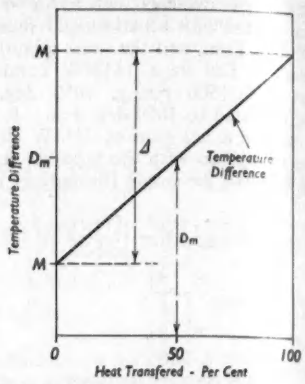


Fig. 10—Equivalent heat transfer diagram

T_i can be found more quickly from the expression

$$T_i=T_m-C(t_1-t_2)^2/(T_m+460) \quad . \quad (15)$$

where

T_m=mean level of heat intake curve on temperature—heat diagram, deg. Fah.

which becomes

$$T_m=\tfrac{1}{2}(t_1+t_2)-D_h/F_d \quad . \quad . \quad (16)$$

when the reactor coolant has constant specific heat. The factor C has the values shown in Table V, item 1, for a cycle without preheaters or superheaters, assuming that the temperature difference is $(t_1-t_2)/N$ between adjacent pressures.

Table V—*Values of C for Equation* (15)

Basis	Number of steam pressures, N				
	1	2	3	4	5
(1) Without nuclear preheating and superheating	0	0·0625	0·074	0·078	0·080
(2) With nuclear preheating and superheating	0·037	0·075	0·083	0·085	0·085

Slightly higher values of C apply for a cycle with preheaters and superheaters. The calculations in Table II are based on the values of C shown by Table V, item 2. The approximation referred to in the text of the article is $C=0$, i.e. $T_i=T_m$.

The cycle efficiency for a finite number of feed heaters n is :

$$\eta_{th}=\frac{T_i-T_r-x/n}{T_i+460-x/n} \quad . \quad . \quad (17)$$

where

$$x\simeq\frac{(T_f-T_r)^2}{(T_f+T_r+920)} \quad . \quad . \quad (18)$$

T_f=feed temperature, deg. Fah.

Acknowledgements

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References

[1] "A New Power Generation Milestone," *Electrical World*, Vol. 139, 1953, No. 26, page 72.

[2] Brown, T. W. F., "High Temperature Turbine Machinery for Marine Propulsion," *The Chartered Mechanical Engineer*, Vol. 1, April, 1954, No. 4, page 162.

[3] Hinton, Sir Christopher, "Nuclear Reactors and Power Production," *The Chartered Mechanical Engineer*, Vol. 1, May, 1954, No. 5, page 235.

[4] Reports to the U.S. Atomic Energy Commission on Nuclear Power Reactor Technology by Four Industrial Groups. *A.C.E.*, May, 1953 (Abstract in *Nucleonics*, Vol. 11, June, 1953, page 51).

[5] Smyth, H. D., "The Development of Nuclear Power for Peaceful Purposes," *Electrical Engineering*, Vol. 73, June, 1954, page 498.

[6] Elliott, R. D., "Economics of Steam-Temperature Selection in Nuclear Power Plants," *Nucleonics*, Vol. 10, February, 1952, page 57.

[7] Robbins, C. H., "Low Temperature Steam Power Cycles for Water Cooled Reactors," *Nucleonics*, Vol. 11, January, 1953, page 42.

[8] Cockcroft, Sir John, "Atomic Power Stations," *The Times Electricity Supplement*, December, 1953.

[9] Cockcroft, Sir John, "Atomic Energy Research at Harwell," *Atomic Scientists' Journal*, Vol. 3, No. 4, 1954, page 182.

Plants for the Production of Anti-Knock Compounds

No. II—(*Concluded from page* 123, *July* 23*rd*)

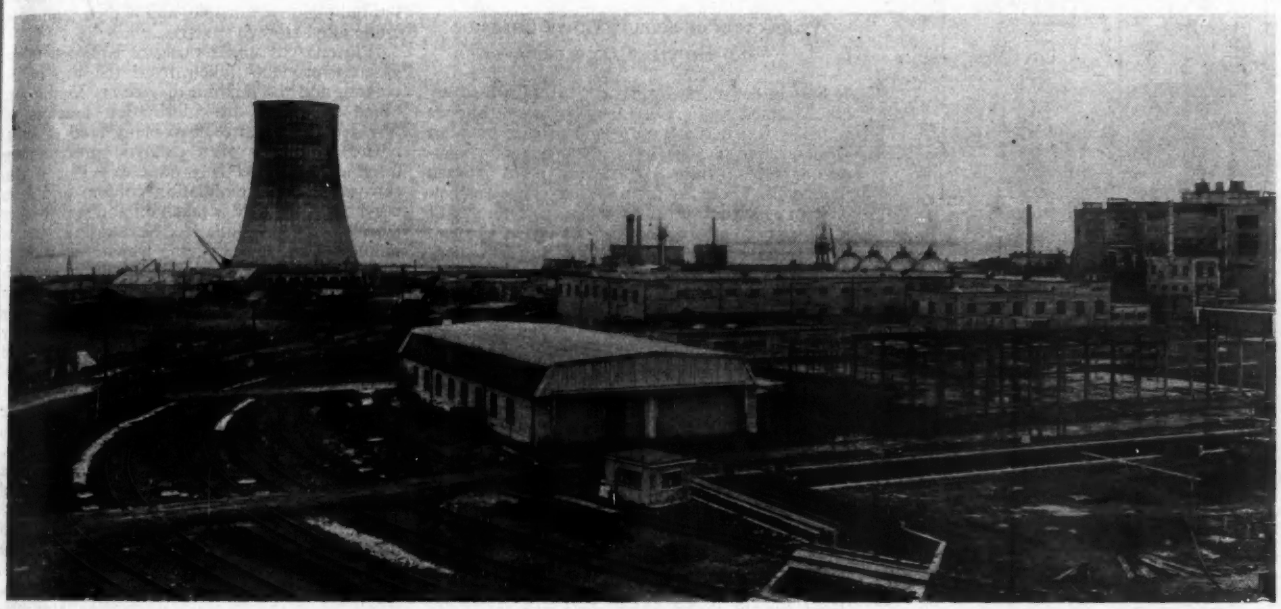
The Associated Ethyl Company, Ltd., after the war realised that the manufacturing capacity of its plant was insufficient to satisfy the demand of the world's markets for anti-knock compounds. Two-thirds of requirements had to be purchased from the dollar area and to save "hard" currency the company decided to increase its productive capacity. The scheme involved the building of a plant, in Anglesey, for the extraction of bromine from sea water and the construction of plants to produce sodium, ethyl chloride, ethylene dichloride and tetraethyl lead at Ellesmere Port.

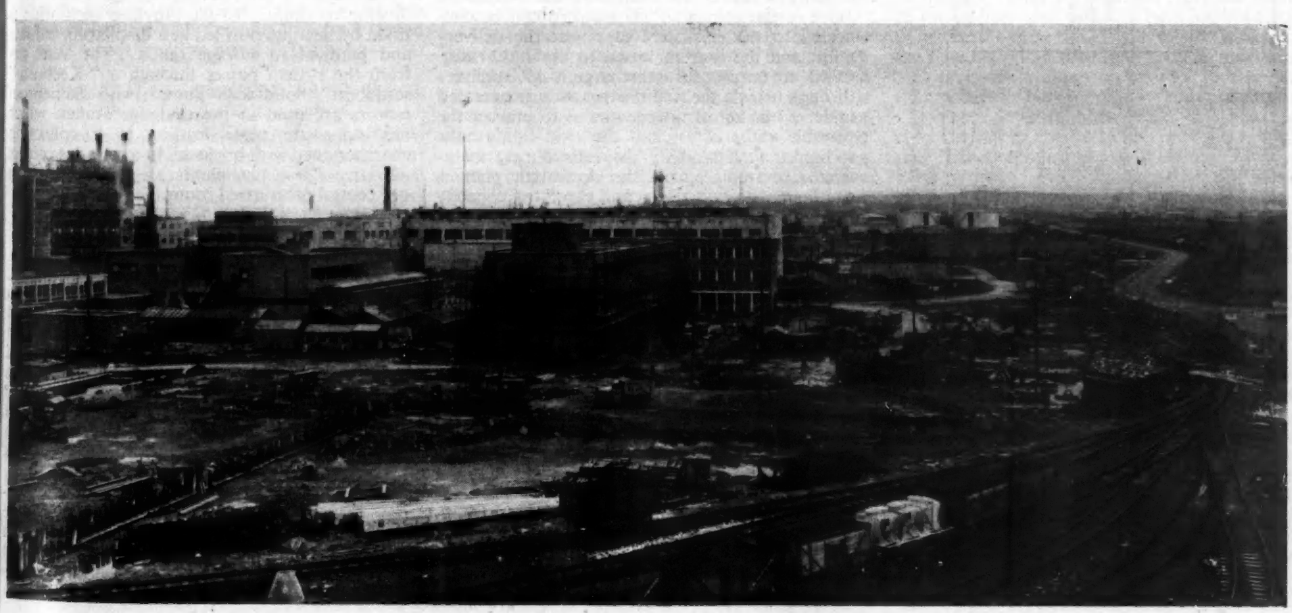
Tetraethyl Lead Plant at Ellesmere Port

SEVERAL factors influenced the decision to build the new tetraethyl lead plant at Ellesmere Port, of which we give a general view in our illustration. The site was available, it was conveniently near the Stanlow refinery of the Shell Refining and Marketing Company, Ltd., and it was in an area where supplies of salt were plentiful. Access to a railway was a relatively easy matter and the site had a frontage on the Manchester Ship Canal, while access to the River Mersey gave ready means of shipment of the final product to the world's markets.

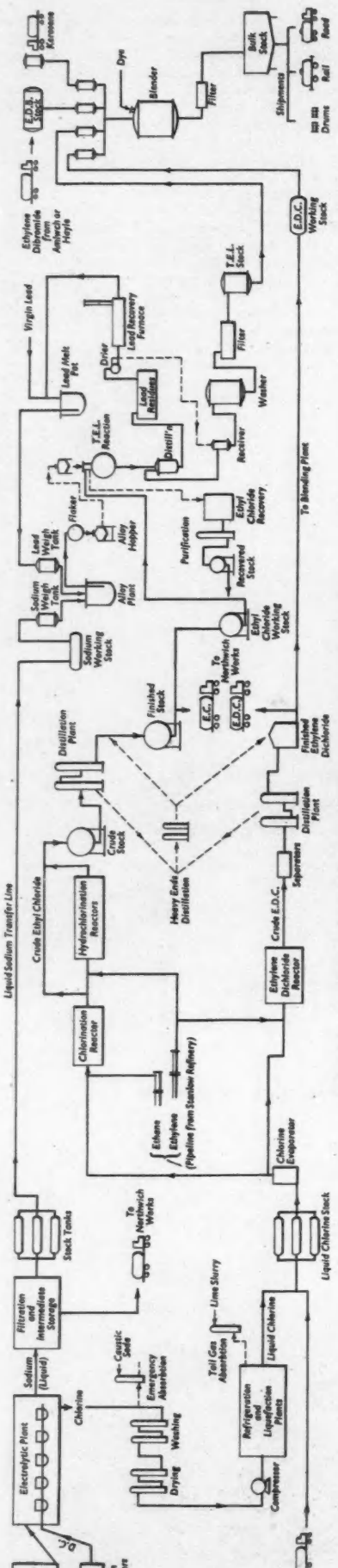
The site covers over sixty acres and upon it has been built the special plant designed to produce tetraethyl lead and to ensure that all the various chemical reactions, critical or otherwise, will take place safely and under full control. Such a project bristled with difficulties and has called for much ingenuity, and the design and building of individual process plants on the part of the company's engineering staff. Apart from the need for careful control to eliminate dangers due to the thermal instability of tetraethyl lead, many problems in both mechanical and chemical engineering were presented by the need to avoid the occurrence of leaks of toxic material, the provision of adequate ventilation and the right material to resist the attack of the highly corrosive gases and liquids which have to be piped from one section of the plant to another.

The poor bearing quality of the ground surface and the compressibility of the clay bearing strata, presented civil engineering problems: 9000 Franki piles were driven to support buildings, plant and tanks, and this method of support necessitated heavy and complex flooring systems. Soil compressibility called for elaborate





Two views of the Ellesmere Port works showing the cooling tower, the tetraethyl lead buildings and (below) the sodium plant



Schematic diagram showing flow lines of the anti-knock compound plant

provision for settlement and particular processes required great attention to floor finish to give protection against spillage of acids and to prevent damage by plant vehicles. Roofs are generally of flat concrete construction, finished off with smooth asphalt, and the walls of the process buildings incorporate 12in by 6in precast concrete cladding up to 20ft in length. Below ground process and service piping systems are housed in wide channels formed of reinforced concrete inverts and reinforced concrete or reinforced brickwork walls. To provide for the washing of floors and to carry away the different effluents, there is an elaborate drainage system, which involved the construction of eight underground pumping stations. There is also a sewage treatment works, including an underground pumping station, 23ft deep by 26ft diameter, to provide for the surge of water occurring at the end of shift periods.

For the production of tetraethyl lead, the main materials required are lead, sodium, ethylene and chlorine. The lead is imported from Broken Hill, Australia, salt provides the sodium and chlorine, additional liquid chlorine is brought in, and hydrocarbon gases are piped in from the Stanlow refinery. Our flow line diagram indicates the order of the various processes involved.

Production of Sodium, Ethyl Chloride and Ethylene Dichloride

Salt is delivered by road, to a two-storey steel framed sodium building, in special hopper vehicles which discharge, under cover, into an underground pit. From here it is moved by conveyors which raise and deliver it to storage hoppers. These in turn feed a conveyor belt system which delivers the salt to a large number of discharge points, where the salt is fed through chutes to individual Downs cells. In this battery of cells, the salt is fused and continuously electrolysed into sodium and chlorine. In order to reduce the working temperature of the cell, calcium chloride is also added as a constituent of the fused electrolyte. By utilising the different densities of fused electrolyte and sodium, the liquid sodium from the cathode is transferred into a small receiver, integral with the cell, and this is tapped at intervals to discharge into an insulated portable container. Fork lift trucks transfer the containers to a point where the contents are discharged into settling vessels fitted with fine wire gauge filters. The sodium is separated in these vessels from a sludge which consists of both sodium and calcium. The liquid sodium is drawn, under vacuum, into a transfer tank and then into four induction-heated overhead storage tanks which discharge to 45-ton capacity tanks at ground level. From the overhead tanks there are arrangements for discharging the sodium into specially designed insulated road tankers, fitted with induction heating coils, which can deliver the sodium to the Northwich plant of the company. These coils can be connected to the electricity supply at the delivery point and the sodium raised to about 120 deg. Cent. to ensure easy discharge. All receivers through which the sodium passes are operated under a blanket of nitrogen so as to prevent the possible entry of air and the oxidation of the sodium. For handling the cells during maintenance or replacement, the electrolytic plant is equipped with two 15-ton and two 5-ton capacity Irving cranes.

The other product from the cells is hot dry chlorine gas, liberated at the anode, which is drawn by suction to the washing and drying plant, where the gas is washed by water sprays in earthenware towers partially packed with "Raschig" rings. For drying, sulphuric acid is circulated in three concentrations, namely 50, 75 and 98 per cent, in successive ring-packed earthenware towers.

After drying, the gas is first compressed to about 30 lb per square inch by vitriol-sealed Nash rotary compressors, before being piped to the liquefiers, which are cooled by Hall's carbon dioxide refrigeration equipment. Here the compressed chlorine is liquefied by being cooled to −20 deg. Cent. in a primary liquefier and to −50 deg. Cent. in the secondary liquefier.

The liquid chlorine is collected in intermediate storage tanks prior to discharge by dry air in main storage tanks, each of 30 tons capacity. The compressed air is supplied by Hamworthy compressors at a pressure of 175 lb per square inch.

In the event of a breakdown of the liquefaction plant, a caustic soda absorption plant is installed to take up the chlorine from the cells, which can be delivered by a fan into the packed absorption towers. To absorb the tail gas from the liquefaction plant and vent gases, there are two lime slurry towers, the lime slurry being provided by a Dorr-Oliver lime slaking plant. Fans feed the gas to the towers.

Chlorination Processes

The liquid chlorine, as required by the processes, is transferred by means of compressed dry air, to the chlorine evaporator, where it is vaporised by hot water in a horizontal shell heat exchanger. In one of our photographs we reproduce a general view of the chlorination group. Ethane from the Stanlow refinery is mixed with the chlorine before entering the reactor and reaction takes place. This exothermic reaction produces hydrochloric acid gas and crude ethyl chloride gas. The cooled gas is piped to a distillation plant where the crude ethyl chloride is separated in the column, which operates on the bubble tray principle, and is then pumped to crude ethyl storage spheres.

Ethylene gas under pressure is added to the gaseous products taken from the top of the column and the mixture of gases is compressed, piped to the hydro-chlorination reactors, of which there are three, two being used in series where by means of a catalytic process more ethyl chloride gas is produced. This is also separated in the distillation column and again ethyl chloride liquid is taken off and sent to crude storage. A propane refrigeration system is employed in the process, which incorporates two two-stage Brotherhood compressors, each driven by a 600 h.p. geared turbine taking steam at 400 lb per square inch gauge and exhausting at 50 lb per square inch to the factory low pressure steam main. A battery of Sigmund pumps fitted with "Flexibox" seals suitable for the materials being handled is used.

From the crude stock sphere the ethyl chloride is pumped to two distillation columns working in series, to remove heavy and light impurities, respectively. The finished ethyl chloride is pumped to storage spheres. Vents are collected to a stack in the north-east corner of the site.

With the completion of the production of ethyl chloride it is necessary to consider the production of ethylene dichloride which is required for the final blending process. Chlorine, produced in the chlorine evaporator, and ethylene, piped from Stanlow refinery, are reacted together in a reaction system to form crude liquid ethylene dichloride. This is washed and the liquid is collected in a settling tank made of "Keebush," a bonded plastic, the water overflowing to drain. Crude ethylene dichloride is dried by heating, purified in a distillation column and pumped to storage tanks. The vent gas from the system passes through a "Keebush" scrubber. Solid lead pumps with flameproof motors are used in the drainage system which has stoneware pipes leading to a collecting chamber lined with bricks set in a resinous cement mortar. These two plants are controlled from one central pressurised room.

Tetraethyl Lead Production

Having described the preparation of sodium, ethyl chloride and ethylene dichloride the next step in the process is the manufacture of a lead sodium alloy. In a steel-framed lead melt recovery building, stacks of lead pigs are loaded by an Irving grab of 3800 lb capacity, into the lead melt pots, which are low-frequency induction heated vessels from which submerged vertical spindle Pulsometer pumps transfer the molten lead through heavily lagged 2in diameter pipes to induction heated scale tanks in the alloy plant. To prevent the lead solidifying the pipelines are resistance heated, the metal of the pipe acting as the resistance. Associated with the lead melting plant is the lead recovery plant and adjoining the building are the sludge pits which take the solid by-products and effluent

from the tetraethyl lead reaction. A 4·5-ton overhead grab picks up the sludge, raises and deposits it in a hopper, from the bottom of which a screw conveyor feeds the sludge into a steam-jacketed dryer, the steam being supplied at 200 lb per square inch, from which the dried sludge drops into a screw conveyor for delivery to a Brayshaw recovery furnace.

Vapour taken off, under slight vacuum, during the sludge drying operation, and consisting of tetraethyl lead and water, is condensed and the condensate is passed to separators from which the tetraethyl lead is run off at the bottom and drawn by vacuum to the tetraethyl lead building. In the furnace, which has a soapstone bed, and can be fired by oil or gas, salt slag is removed for further lead recovery. The lead passes from the furnace via a trough to an intermediate stock pot from whence it can be pumped either direct to the melt pots, to save the latent heat, or to suit process requirements, to a Fraser and Chalmers plant, where it is cast into pigs on the continuous casting system. The pigs are delivered to the stock outside the building by a slat conveyor.

There are three lead recovery units and they play an important role since in the manufacture of tetraethyl lead only 25 per cent of the lead is converted, so that 75 per cent has to be recovered and returned to process. Other points to be noted throughout the building include the careful attention paid to ventilation, for the safe removal of lead dust, there being fifteen changes of air per hour; exhaust ducts lead to all points of the plant where there is any chance of lead in any form entering the atmosphere. A vacuum cleaning plant is fitted, it being possible to plug-in to a suction line at a number of points.

In the two-storey, steel-framed, lead-sodium alloy building weighed quantities of lead and of sodium (the sodium being drawn from the stock tanks by vacuum through lagged resistance heated lines, to a working stock tank and thence to a scale tank) are run into an alloy manufacturing pot and stirred by paddle agitators. The reaction is exothermic and the pot is cooled by "Dowtherm," which operates on a closed system and is water cooled. Vertical spindle Pulsometer pumps transfer the lead-sodium alloy to a distribution pot and then to a battery of flaking machines fabricated to the company's design. The brittle alloy flakes drop down chutes to specially designed hoppers which are filled in closed booths. There are two 20-ton runway beams and an 80ft high extract stack, while the ventilation arrangements provide for twenty-five changes per hour.

The filled hoppers are transferred by fork lift trucks to the two reinforced concrete-framed tetraethyl lead buildings, where they are raised to the operating floor by means of two 2·5-ton Morris hoists. The contents of the hopper are discharged into the autoclave. An excess quantity of ethyl chloride, delivered from working stock to a scale tank, is then gradually fed into the autoclave in which the alloy flakes are stirred by paddles, the reaction being as follows :—

$$4\,Na\,Pb + 4C_2H_5Cl = Pb\,(C_2H_5)_4 + 3Pb + 4NaCl$$

The reaction is exothermic and the gas given off is led to an oil-cooled reflux condenser from which the reflux is returned to the scale tank and the non-condensable or "sniff" gas is bled off to a refrigeration plant. At the end of the reaction there is a primary recovery of the unreacted ethyl chloride. This is driven off by circulating hot water through the jacket of the autoclave, and then piped to the refrigeration and recovery plants and thence to stock. Here the recovered ethyl chloride is passed to a rectification column and then on to a recovered stock tank for reuse.

The process is fully instrumented and control panels give a continuous recording of the pressure in the autoclave, the temperature of the cooling water and of the vapour passing to the reflux condenser.

The reaction mass from each autoclave of the battery is passed into an associated still containing water which is agitated in order to prevent the settlement of lead-containing solids. Steam is injected into the still and there is a secondary recovery of ethyl chloride. The ethyl chloride, followed by tetraethyl lead and water, pass through a water-cooled condenser and on to a separator from which the ethyl chloride is piped to the refrigeration plant and then eventually to stock for reuse in the process. The tetraethyl lead and water are collected and allowed to settle. From the settling tank the tetraethyl lead is passed through a cutting glass, which serves to separate the tetraethyl lead from the water and sludge which are passed into a sludge tank. The lead sludge from the still is piped to the sludge pits, which, as previously noted, are situated along the side of the lead melt and recovery buildings, and from the pits the sludge is treated, in a manner already described, to recover the lead for reuse.

Careful consideration has been given to the ventilation of the tetraethyl lead buildings and the fan capacity is sufficient to provide about thirty complete changes of air per hour. The fans, which are belt driven from electric motors, were supplied by Brook's Air and Heat Systems, Ltd., and draw air in through high-pressure hot water heat exchangers. Another point to notice in the buildings is the employment of flameproof fluorescent lighting fittings which are arranged so as to give a good standard of lighting despite the difficulties set by the layout of the process equipment. It is understood that although initially expensive the system will effect a sufficient saving in consumption of electricity to justify itself economically.

From the tetraethyl lead building the crude tetraethyl lead passes to the washing plant, which is housed in two reinforced concrete framed structures, and from a tank at ground level it is transferred by Pulsometer pumps to the top of the building, where it is subjected to a settling process. The tetraethyl lead passes through bag filters to a weigh tank ready for transfer to the blending plant. The ventilation plant was designed by Brook's Air and Heat Systems, Ltd.

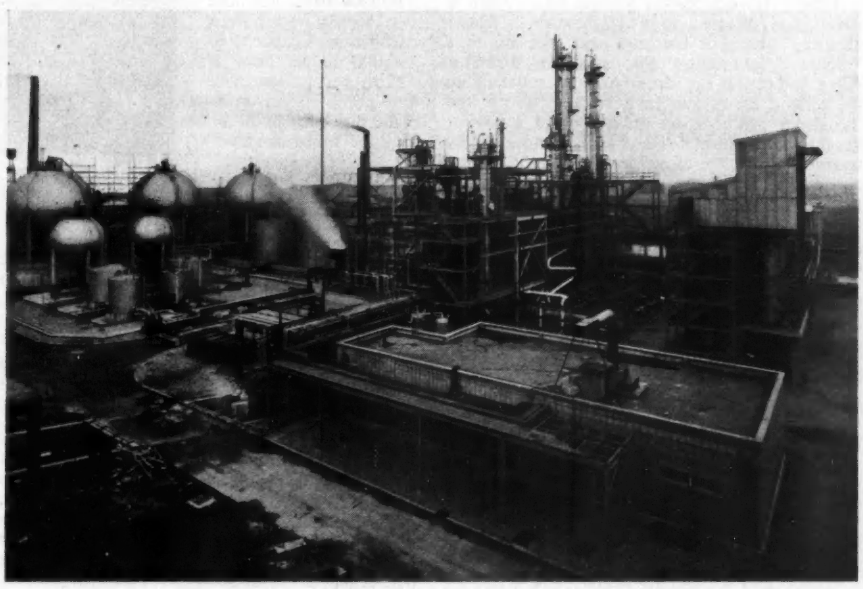
Before passing to the blending operation there is need to notice briefly the ethyl chloride rectification plant which was mentioned earlier in connection with the recovery of excess ethyl chloride from the tetraethyl lead process. The plant, which was designed and erected by the Lummus Company, consists of a continuous distillation column and the ethyl chloride passes through a heat exchanger where it is warmed by the final product as it passes on its way to the scale tank and later to the rectified ethyl chloride sphere. From the heat exchanger the ethyl chloride enters the distillation column at about half height, the light ends are vented and the bottoms pass through the reboiler. There are four storage spheres, as shown in an illustration on page 154, one for crude recovered from the tetraethyl lead building, one for rectified ethyl chloride, and two for the pure ethyl chloride. Associated with the process of the recovery of ethyl chloride is the central refrigeration plant which has been supplied by L. Sterne and Co., Ltd., and is housed on a steel-framed structure cladded between the ground and first floor only and equipped with two 8-ton runway hoists.

Blending of Anti-Knock Compounds

With all the process work completed and the necessary component materials in stock, they can now be blended to produce "Octel" anti-knock compounds. This is done in a steel-framed building equipped with a 5-ton runway hoist, two self-supporting extract stacks, and a ventilation system which provides twenty-five changes of air per hour. Tetraethyl lead is pumped to a scale tank in the blending building from the washing plant; ethylene dichloride is pumped from storage to two stock tanks and then to a scale tank; kerosene delivered by road is stored in two stock tanks; and ethylene dibromide, brought in by road and rail from the bromine plants, is discharged to three stock tanks placed in a heated building, while the dye, used for identification purposes, is stored in kegs. All the component materials pass through scale tanks at the top of the building to the blender which is carried on scales and operates on the jet mixing principle, in which a pump draws liquid from the bottom of the blender and injects it back again to assist in mixing the materials. After mixing is complete the blend is pumped to intermediate stock tanks and from there flows by gravity to the drum filling plant or bulk storage. From bulk storage the blend flows to scale tanks and then runs either to rail or road tankers. For use in motor fuel the compound is dyed yellow, while the aviation mix is dyed blue and does not contain ethylene dichloride.

For drum filling the 45-gallon steel drums enter the bay, from the drum reconditioning plant, on a roller conveyor, and each drum passes over a tare weighing machine and is then tipped on its side and the service bung removed immediately before entering an enclosed filling booth. Here a weighed amount of anti-knock compound is allowed to enter the drum, the supply being automatically cut off when the correct weight is reached. The dip pipe is raised and the drum is moved along the booth to have the inner bung fitted and then, after checking for leaks, passes over check weigh scales and stands, bung downwards, for twenty-four hours to check for any leaks before fitting the outer bung. The drum is now transferred to the pad and labelled ready for shipment.

The drum reconditioning plant, built by the Carrier Engineering Company, Ltd., has an overall capacity of fifty drums per hour and from



General view of the chlorination group, including the Horton spheres tank platform

the stock of returned drums those in an undamaged condition are selected for reconditioning. In the building each drum is forwarded to a washing machine which automatically cleans the exterior surface, the drum being immersed in a cleansing fluid, rotated, wire brushed, spray rinsed and then left to drain. The inner and outer bungs are removed and sent to a separate treatment plant and a vacuum lance is used to remove any liquor before the drum enters the interior washing machine. Here the drum is registered with the bunghole downwards and the interior is washed by four jets, two using hot water, one using steam and one using hot compressed air, in progressive stages. To remove toxic fumes this machine is served by a water washed exhaust system. After washing, the drum is decanted through an up-ender to a roller track where it is inspected in order to decide upon future treatment.

Should internal rusting be noted then the drum is directed to an internal chain rumbler and passes once again through the internal washing machine. At this point a service bung is fitted. If the exterior surface of a drum is rusty it is directed to a Tilghman's "Wheelabrator," for shot blasting, and then on to a "Schori" automatic zinc spraying machine. After inspection the drum may be touched up by a hand spray gun in a suitable booth and the drum proceeds by gravity roller conveyor to the paint shop. Here it is automatically transferred to an overhead conveyor which carries the drum through the automatic spray paint machine, the flash-off tunnel and the stoving oven on to the cooling line. From this point the drum is transferred to a gravity roller conveyor leading to the filling bay.

The bungs, after removal, are placed in a wire basket resting in a portable tank containing a decontaminant and the tank is wheeled to the entry of the bung cleaning plant. The basket is lifted out, traversed and lowered into a cleaning tank and then, after a suitable period, is removed and put into a tank containing acid. This is followed by a rinse and then the bungs pass to a thread-cleaning machine.

The drum external and internal washing machines and the paint shop are in flame-proof areas and between these sections and the non-flame-proof parts of the plant are pressure air locks. As part of the equipment there is a shot recovery plant associated with the "Wheelabrator" and a plant to recover zinc from the spraying machine.

Auxiliary Services

A considerable amount of ancillary equipment is required in connection with the various processes and plant buildings, such as steam, compressed air, nitrogen and cooling water, &c. All the steam necessary is generated by two John Thompson "Beta" water-tube boilers, each of which has an evaporation rate of 75,000 lb of steam per hour at 400 lb per square inch pressure and superheated to 630 deg. Fah. Each boiler has four fusion welded drums and water walls and is designed to produce superheated and saturated steam. There is a water softening plant of 7500 gallons per hour capacity, housed in a two-storey reinforced concrete structure, and two Weir's feed pumps each having a capacity of 190,000 lb per hour at 525 lb per square inch. One pump is driven by a 200 h.p. electric motor and the other, a standby, is turbine-driven. Each boiler is fitted with the maker's carrier bar chain grate stoker and submerged ash conveyor, into which the ash drops, is quenched and carried forward on a rubber belt and up to a 30-ton bunker. Besides burning coal the boilers are fitted with gas-burning equipment in order to burn fuel gas arising from the processes. There is one forced draught fan capable of delivering 30,000 cubic feet per minute at 3·5in w.g., and one induced draught fan rated at 60,000 cubic feet per minute at 5·5in w.g. per boiler. There is in addition one dust collector booster fan and one secondary air fan rated to deliver 6160 cubic feet per minute at 14in w.g.; all fans have been supplied by Davidson and Co., Ltd. As part of the fuel handling arrangement there is a wagon tippler serving underground rubber belt conveyors which supply a bucket elevator delivering to a distribution conveyor. This conveyor has a capacity of 40 tons per hour and supplies fuel to two 140-ton bunkers.

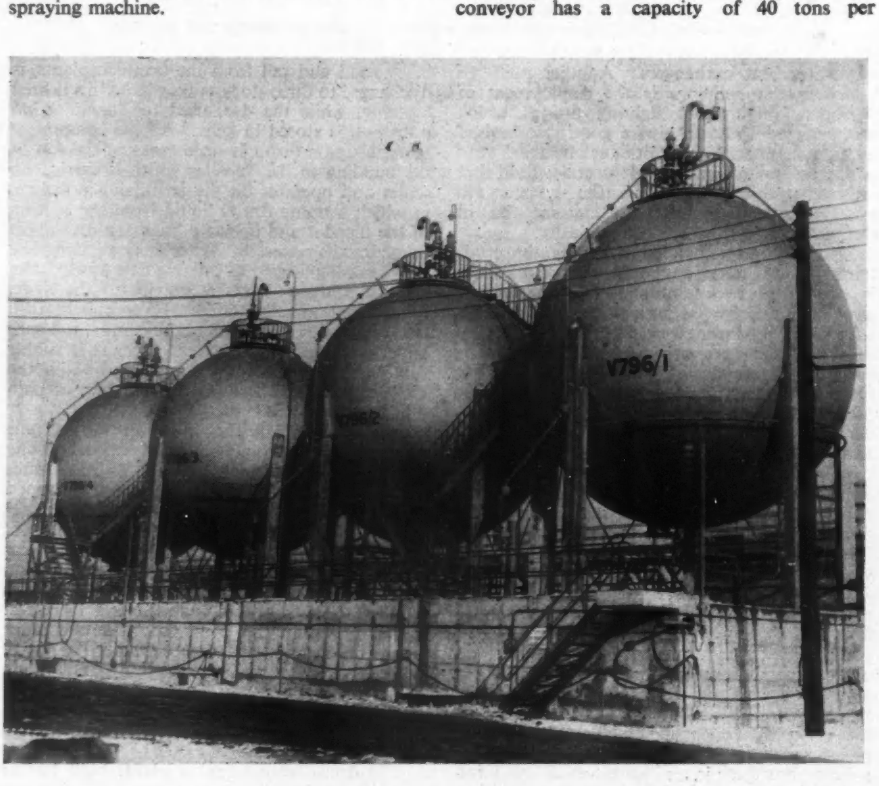
The Sturtevant Engineering Company, Ltd., has provided the high pressure hot water system for space heating, there being two units of 31,000,000 B.Th.U. and one of 20,000,000 B.Th.U. capacity, Saturated steam at 400 lb per square inch heats the water in heat exchangers and the outgoing temperature of the water is 370 deg. Fah., and the return temperature 250 deg. Fah. The water is pumped around the system at 200 lb per square inch by two summer load and two winter load pumps.

Control room in sodium rectifier building showing, on the right, part of sodium rectifier hall

In the main water pump house are installed three Gwynne's pumps, including one as standby, for handling the cooling water which is supplied by the West Cheshire Water Board. Two of the pumps are driven through reduction gearing by Brotherhood turbines, supplied with steam at 400 lb per square inch and 630 deg. Fah., each developing 450 h.p. and arranged to pass out steam at 50 lb per square inch. The third pump is driven by a 450 h.p. electrical motor. For the fire hydrant system there are two pumps, each driven by a five-cylinder National diesel engine, and one pump driven by an electrical motor, each pump being capable of delivering 1000 gallons per minute at 175 lb per square inch. The sprinkler system is served by two pumps, each rated to deliver 1000 gallons per minute at 120 lb per square inch, one driven by a National diesel engine, the other being electrically driven.

Three Broomwade two-stage compressors, each driven by a 125 h.p. electrical motor, supply air for the various services at the rate of 500 cubic feet of free air per minute at 100 lb to 125 lb per square inch, the air being drawn through filters. Provision is made to supply air, which has passed through a silica gel dryer, at 40 lb per square inch for the operation of the instruments installed in the various control panels. Gas is required for certain plants and this is taken from towns supply and passed through a booster, manufactured by the Selas Gas Engineering Company, Ltd., before being distributed at a pressure up to 12in w.g.

It has been mentioned earlier that where sodium and lead alloy are being handled the process is carried out under a blanket of nitrogen to prevent oxidation. To supply the process requirements two nitrogen plants are installed, one acting as an alternative source of supply. In one plant nitrogen is produced from anhydrous ammonia in I.C.I. standard cracking units in which liquid ammonia, from stock tanks, is cracked down to nitrogen and hydrogen and the hydrogen is burnt off in the presence of air under controlled conditions in water-cooled burners. The nitrogen is water cooled and compressed in a Worthington-Simpson, two-cylinder, two-stage compressor to 200 lb per square inch and then passed to storage vessels. In the alternative process, hydrogen, piped from the Stanlow refinery, is burned in air under controlled conditions and the hydrocarbon impurities, which form carbon



Ethyl chloride stock tanks in tetraethyl lead area

dioxide, are absorbed in a scrubber, supplied with caustic soda solution, to leave nitrogen which is dried, compressed and delivered to storage tanks.

A separate set of single-storey, steel-framed buildings are allocated to act as stores for the works, the main stores being equipped with 5-ton and 15-ton Morris electric cranes, while the steel stockyard is served by 3-ton hand-operated crane. For maintenance purposes there is a workshop equipped with a locomotive repair bay, all the necessary machinery such as lathes, drills, milling and shaping machines, welding gear, plate working machinery, and pipe bending machines, and a 7½-ton Morris crane. In a corner of the workshop is a standby single-stage compressor, driven by a six-cylinder Meadows diesel engine, for supplying instrument air at 40 lb per square inch, in the event of a failure of the main electricity supply.

For a number of cogent reasons, coupled with the fact that the Area Board was able to give a satisfactory assurance of a continuous supply of electricity, it was decided not to generate electrical power from the plant's own resources, although owing to the nature of the process work involved it is absolutely essential that a continuous supply is maintained.

A 132/33kV transformer substation was established by the British Electricity Authority, adjacent to the works and fed by two independent 132kV feeders, which are part of the B.E.A. network and can be fed from more than one source. Four 33kV underground feeders supply the factory 11kV main switchboard through 33/11kV transformers and any two feeders can carry the total load of the factory. The switchboard feeds five 11kV ring mains, one feeds the rectifier equipment fitted in a two-storey steel-framed structure serving the electrolysis plant and the others feed nine area substations equipped with Parsons transformers which supply power at 3·3kV and 415V for general plant purposes.

Low-tension switchboards feed switchrooms located in the various process buildings and the supply in the buildings is split down to supply power at 415V, three-phase, and lighting on a 240V system. As a safety measure two independent lighting feeders enter each major process building and, in order to provide against any failure, the lighting is divided between the two feeders. In general, power feeders are taken direct to multi-motor control boards in enclosed switchrooms and the motor drives are controlled from push-button stations. A point of importance is that where switchrooms are in a hazard area they are pressurised by air drawn from a safe source of supply. In the description of the plant reference has already been made to certain other uses of electrical power, such as the low-frequency induction heated vessels, the resistance heated pipelines, the electric blanket heated vessels and the heating of the valves in the liquid metal pipelines. There is also the conversion plant equipped with a battery of B.T.H. pumpless steel tank mercury arc rectifiers for supplying direct current to the electrolytic plant. In our illustration can be seen the control room for the mercury arc rectifiers and part of the rectifier hall. This conversion plant involved a number of problems including the possibility of introducing dangerous harmonics into the supply and to avoid this danger the system was arranged to operate as a forty-eight-phase unit. A further problem also arose in connection with the 11kV power factor correction capacitors, and it was found necessary to introduce, in series with the capacitors, reactors designed to attenuate the major harmonics likely to be produced by the rectifier installation. The British Thomson-Houston Company, Ltd., has supplied most of the motors and all the h.t. switchgear, while Metropolitan-Vickers Electrical Company Ltd., has provided the l.t. switchgear. The multi-motor control boards have been the responsibility of The General Electric Company, Ltd., and Johnson and Phillips, Ltd., has supplied and fitted the main power cables.

In a plant such as this there are many materials which are potentially dangerous if not handled properly and the company has a standard of safety, supported by rules and regulations, designed to make the operations of the plant absolutely safe. All employees are provided with a complete outfit of clothes, for use on the plant, so that their personal clothing cannot be contaminated in any way. There are adequate washing facilities provided in a special two-storey, steel-framed building which also houses a laundry and refreshment rooms. In addition, full protective equipment is supplied to, and a specially trained safety man accompanies, any repair squad when carrying out any dangerous maintenance work, while notices at specific points give clear warning and instructions at places where special precautions need to be taken during the ordinary course of duty. There are masks for protection against dust, canister masks for certain duties and there is an extensive system of piped compressed clean air to provide a system into which an air line gas mask can be plugged.

The civil engineering works for the Ellesmere Port works were carried out by the contractor, George Wimpey and Co., Ltd., the consultants being Messrs. Maunsell, Posford and Pavry, and Sir Alexander Gibb and Partners.

Rye House Generating Station

Rye House generating station, near Hoddesdon, Herts, was formally opened on July 22nd by The Hon. David Bowes-Lyon, Lord Lieutenant of Hertfordshire. The ultimate capacity of the station, as planned, will be 192MW and four of the six 32MW, 33kV turbo-alternators, each with its 350k lb per hour p.f. fired boiler raising steam at 650 lb per square inch and 875 deg. Fah., are at present in service. Sufficient cooling water for one set is available from the River Lea and this supply is augmented by three natural draught cooling towers. Site work was started in 1947 and the first set was commissioned in December, 1951. The station is on two-shift operation and the overall efficiency from January to March this year was better than 25·5 per cent.

ON July 22nd, The Hon. David Bowes-Lyon unveiled a plaque over the entrance to Rye House generating station, to mark the official opening of this plant, which has a present generating capacity of 128MW and is planned for an ultimate capacity of 192MW. The station was projected and designed by the North Metropolitan Power Station Company, Ltd., before the war, but constructional work was deferred until 1947 and, under the Electricity Act of that year, the scheme was taken over by the Eastern Division of the British Electricity Authority. The first generating set was commissioned in December, 1951, and the present installation consists of four 32MW turbo-alternator sets with steam supplied on the unit system, at 650 lb per square inch and 875 deg. Fah. by four 350 k lb per hour boilers.

The station is built on a 100-acre site near Hoddesdon, Herts, with a frontage of 3400ft on the River Lea Navigation system and with railway sidings on the main Cambridge line of the Eastern Region, British Railways. Enough cooling water for the needs of only one turbo-alternator set is available from the River Lea, and the requirements of the existing installation are met by three reinforced concrete natural draught cooling towers, each capable of handling 1,350,000 gallons of water per hour.

The main structure of the station was designed to conform with local amenity requirements and Sir Gilbert Giles Scott was the adviser on the architectural design. As can be seen from our first illustration, the main building presents a rectangular face to the main road on the south. This brickwork face is relieved by the vertical lines of windows on each side and by the block of administration buildings with the main entrance facing the road. The rectangular *façade* masks the difference between the roof levels of the turbine room and mechanical annexe on the right and the boiler-house on the left. To accommodate future plant installation the building will be extended along its main axis at right angles to the frontage depicted in our illustration. Ultimately the boiler-house will be 420ft long by 100ft wide by 100ft high ; the turbine house and mechanical annexe have a combined width of 150ft and a maximum height of 80ft.

As shown in our second illustration on page 156, the station is arranged to accommodate the turbo-alternator sets transversely in the turbine room. Between the boiler-house and the turbine room are the coal bunkers and the mechanical annexe. The electrostatic precipitators are installed between the boiler-house and the chimney. Although the induced draught fans are installed outdoors they are partly protected because of their position at ground level between the precipitators and the main gas flue leading to the chimney.

Flue gases from all the four installed boilers are exhausted via the electrostatic precipitators to a single chimney at the south-west corner of the main building. This chimney, which is brick built, is square in plan, with the corners slightly splayed off. It is 260ft high and the internal dimensions are 26ft square.

Coal Handling Facilities

All the coal supplies for Rye House generating station are railborne from the East Midland coalfields and are delivered to the station reception sidings. Here the works locomotives, manufactured by Robert Stephenson and Hawthorns, Ltd., move and clear the wagons to wagon tippler sidings, where the trucks are winched to the final tipping position. Two side-discharge, weighing wagon tipplers are provided in a separate building, both machines being fitted with dust-removal plant manufactured by Sturtevant Engineering Company, Ltd. The wagon tipplers, manufactured by Mitchell Engineering Company, Ltd., are capable of tipping ten 20-ton wagons per hour.

Underground conveyors feed the coal either to the station bunkers or the coal store beyond the main building to the north. Storage and reclamation is by means of a Beaumont drag scraper plant supplied by International Combustion, Ltd.; it has a capacity of 200 tons per hour with an average haul of 220ft, the scraper size being approximately 150 cubic feet. The initial pile on which the drag scraper works is formed by means of a radial belt conveyor which swivels through an angle of approximately 120 deg.

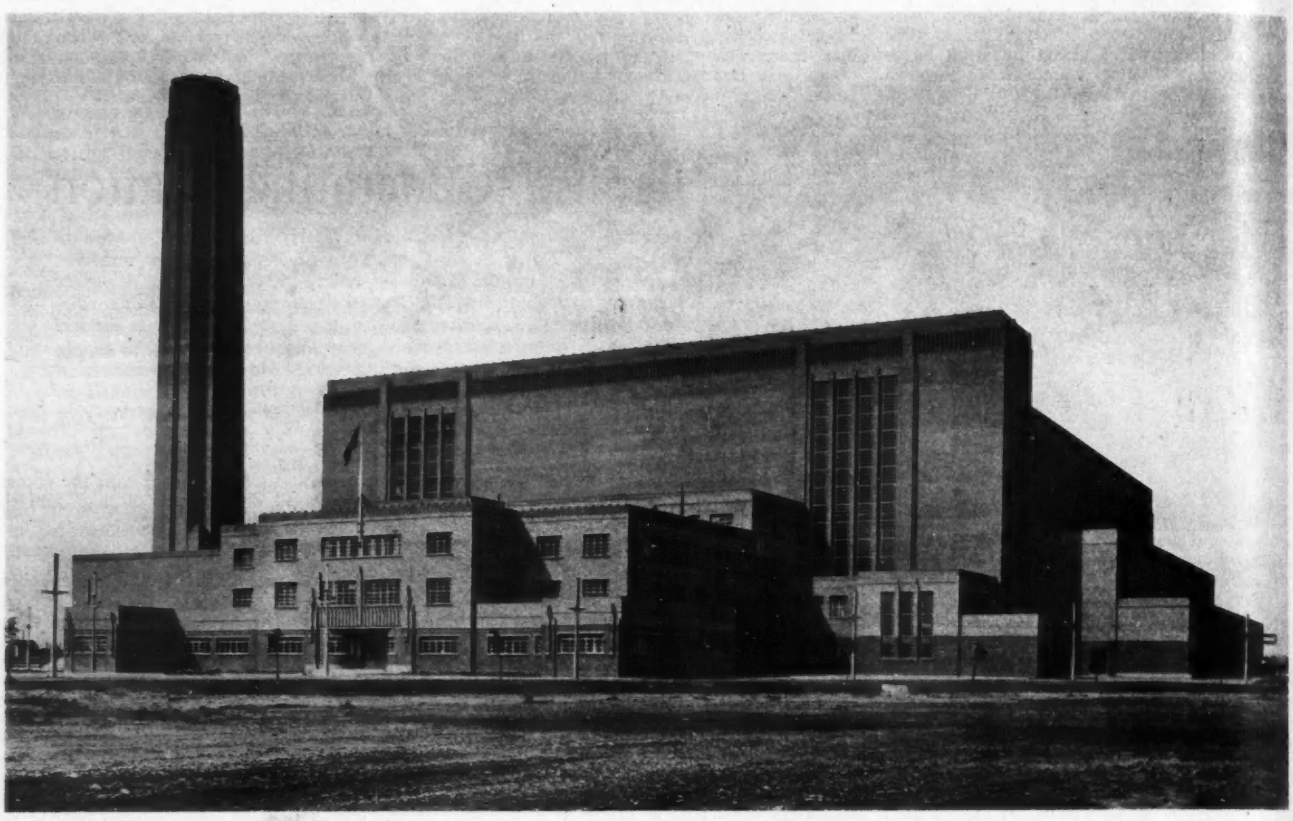
At the station end the conveyors feed the boot of a gravity bucket elevator which raises the coal to the bunker conveyors where a travelling tripper facilitates the stocking of the various bunkers.

Boiler and Auxiliary Plant

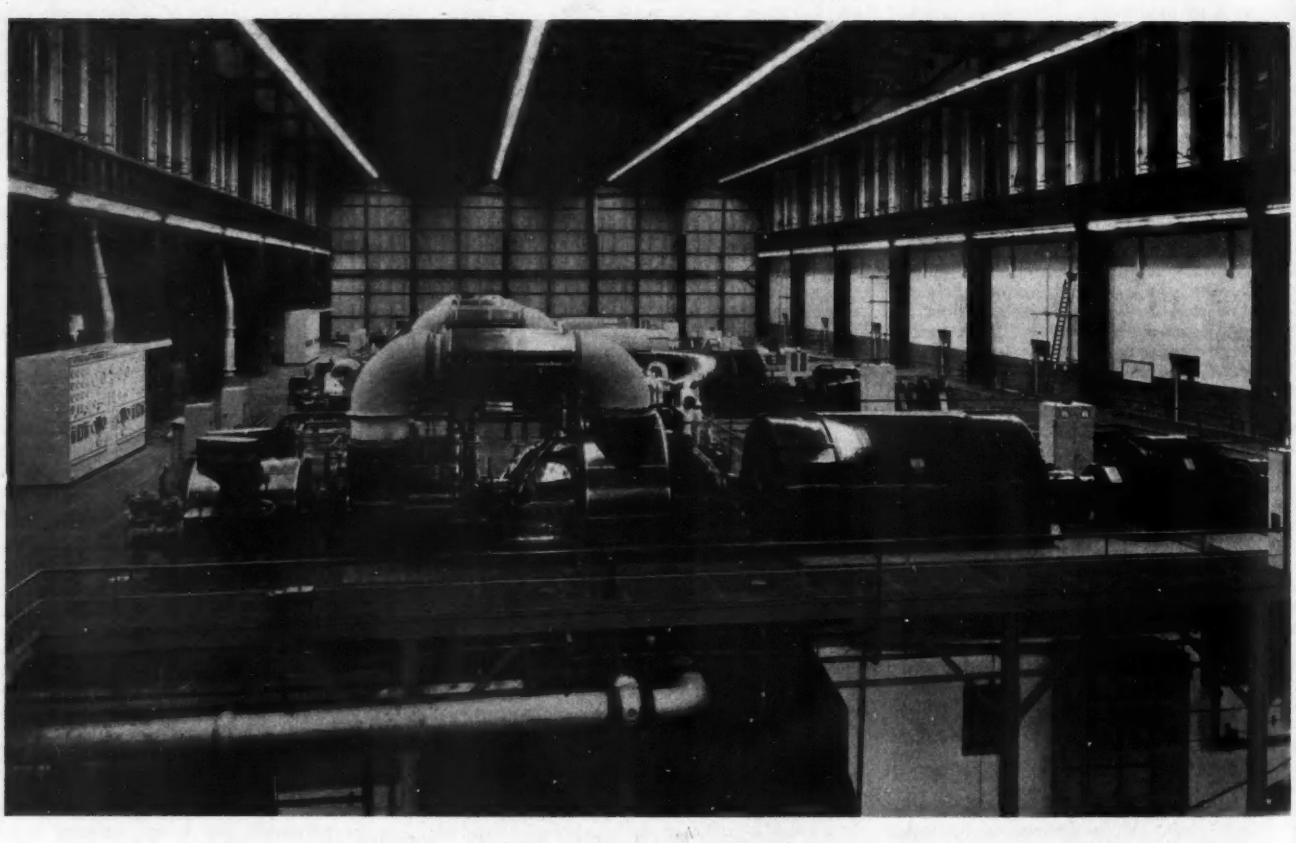
At present the boiler-house installation consists of four Babcock and Wilcox series high-head boilers, each having a maximum continuous evaporation rate of 350,000 lb per hour, with superheater outlet steam conditions of 875 deg. Fah. and 650 lb per square inch. The boilers are fitted with Babcock and Wilcox single-pass superheaters and Bailey water-cooled combustion chambers and are pulverised fuel fired. The economiser is a Babcock and Wilcox integral steaming equipment arranged in two sections, back to back, inside the boiler casing, with water in counter flow to the gases. Each boiler is fitted with Babcock single-nozzle retractable soot blowers and all the units, including fixed jet blowers on the air heaters, can either be operated automatically on sequence control or manually. The control equipment for automatic sequence operation is assembled on a separate panel for each boiler and is floor mounted at operating level. Any blower head can be operated individually as required, and any head can be taken out of service without upsetting the automatic operation of the remainder of the cycle.

There are two Howden-Ljungstrom regenerative air preheaters per boiler, each of which has a heating surface of 55,900 square feet.

RYE HOUSE GENERATING STATION



Rye House generating station. The main entrance and offices are in front of the boiler house and turbine room. The architecture of the building was the responsibility of Sir Giles Gilbert Scott



Turbine room of Rye House generating station. Four 32MW turbo-alternator sets are installed, generating at 33kV

The forced draught fans are Howden single-inlet "Turbovane" sets, there being two per boiler. Each boiler also has two Howden double-inlet induced draught fans. Each fan is driven by a direct-coupled, two-speed electric motor, and the fan vanes are controlled from the boiler control panel through a Lockheed hydraulic system.

Pulverised fuel is fed to each boiler from four Babcock and Wilcox No. 44 "E" mills. A classifier is situated in the top section of the mill and separates and returns the coarse particles of coal back to the grinding section for further pulverisation. Each mill is fed by a slow-speed, rotating-disc table feeder which is designed to give a regular feed over the full range of operation. Primary air is supplied by single-inlet centrifugal fans, the impellers being of backward-curved-blade design and made of high-tensile steel.

Feed water is pumped by Weir ten-stage, horizontal, centrifugal pumps, each capable of normal load output of 193,000 lb per hour, against a normal discharge pressure of 940 lb per square inch. There are three such pumps, all electrically driven, per set and a steam-driven standby pump is also provided for the first two boiler units.

Ash and Dust-Handling Plant

The ash hoppers are of the "Hydrojet" design arranged for side discharge into a sluiceway, which is designed to deal with ash at the rate of 40 tons per hour, with a total water quantity of approximately 1700 gallons per minute. The high-pressure sluicing pumps are single-stage centrifugal sets, each capable of passing 1700 gallons of water per minute against a discharge head of 275ft. Ash is discharged from the sluiceway via a crusher unit into a concrete sump. The crushers are rotary, four-roll machines driven by a geared motor unit of 25 b.h.p.

Single-stage centrifugal pumps discharge the ash-laden water collected in the sump to one of two halves of an elevated ash drainage bunker in the station yard. Each half of the bunker has a capacity of 60 tons, and the discharging gates on the outlets are of water-collecting design. Belt conveyors below the bunker discharge gates allow the drained ash to be loaded into railway wagons or lorries for final disposal. The dust is removed from the precipitator hoppers by hydraulic ejectors which discharge it into a sluiceway where it is delivered to the ash sump. Dust is removed from the sump by connecting a single-stage, centrifugal slurry pump in series with the ash pump, the combination disposing of the slurry to worked-out ballast pits near the site.

Turbo-Alternator Sets

The turbo-alternator sets are of Brown-Boveri design and are made by Richardsons, Westgarth and Co., Ltd. The turbines are three-cylinder, simple tandem, impulse reaction machines operating on stop-valve steam temperature conditions of 850 deg. Fah. at 600 lb per square inch. The h.p. and i.p. cylinders are made of molybdenum cast steel, while the l.p. cylinder is of close-grained cast iron. The blading on the h.p. rotor comprises one row of impulse blades followed by twenty-two rows of reaction blades. There are eighteen rows of reaction blading on the i.p. cylinder, while the l.p. section, being of the divided flow design, has two groups of reaction blading each of five rows. The steam conditions at the i.p. and l.p. section inlets are 610 deg. Fah. at 190 lb per square inch and 212 deg. Fah. at 0·3 lb per square inch respectively. The design steam consumption of the turbines at 100 per cent load is 9·04 lb per kilowatt-hour, with a heat consumption rate of 10,060 B.Th.U. per kilowatt-hour.

The alternators are Parsons machines; the main alternator is rated at 30MW at 3000 r.p.m. and is wound for 33kV, three-phase, 50 c/s generation; the auxiliary alternator, which is integral with the main machine, is rated at 2000kW at 3000 r.p.m., and is wound for 3·3kV, three-phase, 50 c/s generation. The power factor for the main machine is 0·85 lagging and for the auxiliary alternator 0·8 lagging.

Both alternators are air-cooled on a closed circuit system, with an alarm device which operates if the cooling air exceeds a specified temperature. The main air cooler is designed to deal with 70,000 cubic feet per minute when supplied with 900 gallons per minute of cooling water. Air is circulated by means of duplicate ventilating fans, each of which is capable of delivering 70,000 cubic feet per minute of air against a discharge pressure of 16in w.g. when running at a speed of 975 r.p.m. Excitation is by means of direct-coupled main and pilot exciters and automatic voltage regulators of the normally inactive type function in the excitation circuits of main and auxiliary alternators.

Condensing Plant

Each set is associated with a twin-shell, two-pass condenser, the total cooling surface provided in each pair of shells being 40,000 square feet. It is designed to condense 219,000 lb of steam per hour and with the feed heating system in operation the corresponding design vacuum is 28·8in Hg. Under these conditions, the quantity of cooling water required is 23,500 gallons per minute at an inlet temperature of 65 deg. Fah. To protect the turbo-alternators against loss of vacuum a relay-operated device is incorporated in the turbine control which automatically reduces the load progressively in the event of the condenser not being able to maintain a satisfactory low back pressure. The air extraction apparatus comprises standard live-steam, jet-operated, three-stage ejectors with a dry air capacity of 113 lb per hour. The jet steam is condensed by means of two small surface condensers incorporated in the ejector casing through which the condensate is pumped by the extraction pumps. The extraction pumps are vertical-spindle, electric-driven "Pervac" machines supplied by Drysdale and Co., Ltd. There are two pumps per condenser; each has a capacity of 600 gallons per minute and is capable of dealing with the whole of the condensate from the turbine and the cascaded and other drains at maximum continuous rating, including an overload capacity.

Feed Heating and De-aerating System

The four-stage feed heating system comprises one combined l.p. heater and drain cooler and one low-level de-aerator followed by two stages of h.p. heaters. The feed temperature, when the turbo-alternator is generating at maximum continuous rating, is 350 deg. Fah. at the outlet of No. 2 h.p. heater. The l.p. heater and drain cooler has a combined surface of 1000 square feet and is a six-pass, horizontal, low-pressure installation.

The de-aerators are mounted at operating floor level in the mechanical annexe to the turbine room. Each de-aerator is a Richardsons, Westgarth flash equipment with direct contact heating and a horizontal water storage tank. The heating surface is 600 square feet and the unit has a designed flow quantity of approximately 340,000 lb per hour. The two h.p. heaters are Richardsons, Westgarth vertical four-pass, U-tube equipments with cooling surfaces each of 950 square feet. They are provided with automatic by-pass and isolating valves which operate if a high water level is recorded in the unit.

The evaporating plant consists of a vertical, straight-tube unit operating with turbine bled steam and with live steam by the vapour compression method when the turbine is on low load or is shut down. The units are also fitted with raw water preheaters which are capable of raising the temperature of the raw water feed nearly to saturation temperature prior to its entering the evaporators.

Control room at Rye House generating station. Running control is effected from the central desk which is equipped with turbine and boiler-house telegraph transmitters

Circulating Water System

The circulating water system is designed to utilise some of the cooling capacity of the River Lea. Sufficient cooling water is available from the river to meet the requirements of one turbo-alternator set, and the river supply is augmented by three reinforced-concrete, natural-draught cooling towers, each capable of dealing with 1·35 million gallons of water per hour. Each tower is supplied by two pumps which draw water from a condenser discharge culvert which is common to all the condensers. The towers discharge, via their own ponds, to a common inlet culvert into which the river water is also drawn. Thus, all three towers are in parallel with the river supply and can be used singly or in any combination to suit whichever machines are running. Both the cooling tower and condenser pumps are manufactured by Mather and Platt, Ltd., and are of the vertical "Lonovane" design.

Electrical Equipment

Generation is at 33kV and the output of the main alternators is switched at that voltage direct on to the busbars of the main switchgear, which is B.T.H. outdoor equipment having a rupturing capacity of 1000MVA and is arranged in two groups of double busbar form with two

oil circuit breakers per circuit. For feeding the "Grid" the voltage is stepped-up from 33kV to 132kV through four 45MVA transformers, which also function as reactor couplings between the two groups of switchgear.

Supplies for works power auxiliaries are taken from the direct-coupled house service alternators or from the 33kV busbars through one 3MVA transformer per alternator which supply 3kV double-busbar works switchboards. The essential auxiliary plant is divided equally between these two supplies. The 3·3kV supply is again stepped down as required for the low-voltage auxiliaries.

Control Room

The control room is situated in the administration block with easy access to the station. As illustrated on page 157, the control panels are of semi-miniature form, each carrying its own alarm annunciator. Synchronising is carried out at the panels using trolley-mounted equipment, but running control is from a centrally mounted desk which also carries the turbine and boiler-house telegraph transmitters and has logging facilities for the two control engineers. Telephones are installed on the centre portion of the desk which also embodies an ingeniously concealed "night" exchange for dealing with external calls when the main station exchange is not manned.

Main metering equipment and "printometers" are housed in a separate room adjoining the control room.

Main Contractors

The main contractors are listed herewith.

Civil Engineering.—Superstructure and ancillary buildings, Walter Lawrence and Son, Ltd.; steelwork, Dawnays, Ltd.; cooling towers, The Davenport Engineering Company, Ltd.; precipitator housings and 132kV switchgear structure, Bierrum and Partners, Ltd.; circulating water culverts, J. L. Kier and Co., Ltd.; coal-handling substructure, Holst and Co., Ltd.; circulating water system, William Press and Son, Ltd.; railway access and sidings, Thos. Summerson and Sons, Ltd.

Mechanical Plant.—Boilers, Babcock and Wilcox, Ltd.; turbines, Richardsons, Westgarth and Co., Ltd.; alternators, C. A. Parsons and Co., Ltd.; condensers and feed heating systems, Richardsons, Westgarth and Co., Ltd.; Evaporators, Aiton and Co., Ltd.; circulating water screens, F. W. Brackett and Co., Ltd.; circulating water pumps, Mather and Platt, Ltd.; boiler feed pumps, G. and J. Weir, Ltd.; auxiliary pumps, Holden and Brooke, Ltd.; deep well pumps, Hayward-Tyler, Ltd.; precipitators, Lodge-Cottrell, Ltd.; coal-handling plant, International Combustion, Ltd.; ash and dust plant, B.V.C. Industrial Constructions, Ltd.; high-pressure pipework, Stewarts and Lloyds, Ltd.; high-pressure valves, Hopkinsons, Ltd.; low-pressure valves, J. Blakeborough and Sons, Ltd.; air compressor, Broom and Wade, Ltd.; chlorination plant, Wallace and Tiernan, Ltd.; water-treatment plant, John Thompson-Kennicott, Ltd.; vacuum cleaning plant, Sturtevant Engineering Company, Ltd.; automatic fire protection, Mather and Platt, Ltd.; storage tanks, Horseley Bridge and Thomas Piggott, Ltd.; steam locomotives, Robert Stephenson and Hawthorns, Ltd.; turbine house crane, The Clyde Crane and Engineering Company, Ltd.

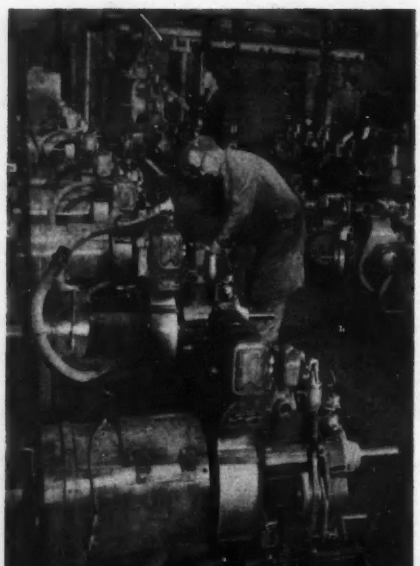
Electrical Plant.—Main switchgear, British Thomson-Houston Company, Ltd.; works power switchgear, British Thomson-Houston Company, Ltd.; main and auxiliary transformers, Fuller Electrical and Manufacturing Company, Ltd.; main and secondary cables, British Insulated Callender's Cables, Ltd.; auxiliary and lighting wiring, Eastern Electricity Board; fluorescent fittings and lamps, Thorn Electrical Industries, Ltd.; motors, Lancashire Dynamo and Crypto, Ltd.

Small Air-Cooled Diesel Engine

We recently had the opportunity of paying a visit to the Causeway Works of Petters, Ltd., at Staines, Middlesex, of which a brief description appeared in The Engineer of December 14, 1951, for the purpose of making a tour of the shops and seeing the company's small air-cooled diesel engine in production. This engine, Mark PAZ-1, is the result of careful development work and actually made its first appearance at the Royal Show at Blackpool last year. Since then the unit has proved itself in service and any adjustments which may have been found to be necessary as the result of running experience have been made. The engine is now coming off the assembly line at the rate of about two hundred per week.

The engine is a single-cylinder, cold-starting, vertical, air-cooled, totally-enclosed, compression ignition unit, working on a four-stroke cycle, and has been designed to permit of a choice of five drives to enable it to act as a power unit for a large number of agricultural and industrial purposes. It is a square engine, having a bore and stroke of 3in, and is basically a diesel version of the company's petrol engine of similar size, so that, with the exception of the cylinder, cylinder head, piston, and cams for the fuel pump, the major components of both engines are interchangeable. It is claimed by the manufacturers that the direct injection combustion system of the PAZ-1 makes for reliability and that the engine requires less maintenance than its petrol counterpart, while the fuel costs are greatly reduced. On a twelve-hour rating the engine develops 1¼ b.h.p. at 1000 r.p.m. and 2½ b.h.p. at 1500 r.p.m. on a fuel consumption of under 0·5 lb/b.h.p./hour, while the maximum torque on a one-hour rating at 1500 r.p.m. is approximately 9·4 lb-ft. The brake mean effective pressure is 62 lb per square inch. It is claimed that the engine has a cyclic variation of 1/78 which makes it suitable for driving generating sets.

The crankcase, which is strongly constructed with integral mounting feet, is of cast iron, while special cast iron is used for the cylinder,



Batch of "PAZ-1" engines undergoing tests

which is deeply finned to promote adequate cooling. Specially designed inlet and exhaust ports are incorporated in the cast iron cylinder head and again there are deep fins to ensure the efficient dissipation of heat. The aluminium alloy piston has an offset hemispherical bowl in its crown and there are three compression rings, two slotted scraper rings, one of which is below the floating gudgeon pin. The design of the inlet port in association with a masked inlet valve and offset bowl in the piston crown is intended to impart maximum swirl to the air and so attain maximum combustion efficiency. An "H" section steel forging forms the connecting-rod, and this is machined to take thin wall precision bearings, the top half being copper-lead lined and the lower half white metal lined. A similar white metal bearing carries the main crankshaft.

Totally enclosed pressure lubricated valve rockers are provided and are easily accessible for inspection and adjustment, while a totally enclosed centrifugal governor is housed on the gear cover. There is provision for making small permanent changes in speed. Fuel is supplied by gravity from a tank of 1 gallon capacity through a fabric filter and the injection pump, which is mounted on the gear cover and is operated by a plunger actuated from the engine camshaft, delivers the fuel to a valve having a nozzle with three 0·009in diameter holes. For lubrication purposes there is a plunger pattern pump, which draws oil from the wet sump, of 6·75 pints capacity, through a gauze strainer and delivers the oil under pressure through externally fitted pipes to the main bearings. Other external pipes supply the rocker shaft and extension shaft bearings, and the connecting-rod big-end bearing is lubricated by oil, which passes through a drilling in the crankshaft, from the rear main bearing. The camshaft and cylinder walls are splash lubricated.

A combined flywheel fan with flat radial vanes, so that the fan operates with equal efficiency when rotating in either direction, delivers cooling air via removable sheet metal ducting to the cylinder and cylinder head. Other equipment includes an oil-wetted air cleaner and a pepper pot silencer. For starting there is a detachable handle which fits either the crankshaft or the half-speed shaft, and it is claimed that starting is unaffected by temperature conditions. Our illustration shows the engine, which has a dry weight of 265 lb, undergoing tests.

Integration of Hydro and Thermal Generation in Great Britain*

No. I

By J. D. PEATTIE, B.Sc., M.I.E.E.,† and A. A. FULTON, B.Sc., M.I.C.E., M.I.Mech.E.‡

This paper describes, briefly, the development of hydro-electric and thermal generation in Great Britain, and examines the present extent and future prospects of their co-ordination. It shows that in 1952 hydro-electric stations supplied 22 per cent of the Scottish output and were responsible for 510MW of the total of 1668MW of plant in all Scottish stations. Referring to the possible pattern of generation in Scotland in the early 1960s it is stated that hydro-electric stations are expected to supply 3500 million units annually, or 30 per cent of the total Scottish output: a potential hydro-electric output of about 10,000 million units annually is shown by recent investigations.

The first significant integration of water and steam power occurred in 1926, when the Bonnington and Stonebyres run-of-river stations with 16,000kW of plant and an average annual output of 80,000,000 kWh at the Falls of Clyde in Scotland were added to the Clyde Valley Electric Power system to supplement the outputs, amounting to about 200 million kWh in 1929, of that company's three interconnected thermal stations.

The construction of the 132kV grid in the early 1930s had a profound effect on development of generating stations in Great Britain. So far as hydro stations were concerned, it widened the basis of planning and design. New hydro plant had no longer to be planned to supply in isolation a restricted load. It could be planned to contribute to the general pool of existing and new thermal plant from which consumers over a wide area drew their supplies.

In 1930 and 1932 the Rannoch and Tummel stations, with an installed capacity of 82MW, and an average annual output of 266 million kWh, were built and connected to the 132kV grid in Scotland and were operated in conjunction with the thermal plant there. In 1935, the Galloway group of five hydro stations were connected to the 132kV grid between Scotland and England, and operated in conjunction with thermal plant in Scotland and North-West England. They have an installed capacity of 103MW and an average annual output of 224 million kWh.

In comparison with the water power potential in Scotland, these developments were small, but progress became more rapid after the North of Scotland Hydro-Electric Board was set up in 1943 for the specific purpose of developing water power as an integral part of the wider plans for the regeneration of the Highlands. As a result, a further 315,765kW of hydro plant had been added in North Scotland by the end of 1953. The extent of the progress made with survey, construction and completion at that date is shown in Table I.

Choice of Sites for Generating Stations.—Since 1943, the North of Scotland Hydro-Electric Board has planned and carried out practically

* World Power Conference. Sectional Meeting, Brazil, August, 1954.

† Deputy chief engineer (generation), British Electricity Authority.

‡ Chief hydraulic and civil engineer, North of Scotland Hydro-Electric Board.

all hydro development in Great Britain. The sites were chosen by them, having regard to the extent and location of consumers' demands in their own area and to their further commitment to supply energy to the B.E.A. on the mutually agreed terms.

The sites for thermal stations, developed by the British Electricity Authority, were chosen to secure maximum economy, having regard to location of coalfields and load centres, costs

TABLE I—*Scottish Hydro-Electric Development at December 31, 1953*

State of schemes	Capacity	Estimated average annual outputs
	kW	Million kWh
In operation prior to December 31, 1945	203,890	601
Commissioned between December 31, 1945, and December 31, 1953	315,765	675
Under construction...	417,450	1,277
Under promotion and survey	278,500	986
	1,215,605	3,539

of fuel transport, availability of circulating water, and costs of electrical transmission.

Allocation of the Total Kilowatt Capacity to Individual Sites.—In arriving at the fraction of the total additional kilowatt capacity to be allocated to each individual site, consideration has to be given to the following four main types of station, with no sharply defined demarcation between them :—

(1) Hydro stations remote from load centres have allocated to them kilowatt capacity sufficient only to use the water normally available by running for long hours at about full load.

(2) Hydro stations near load centres have allocated to them kilowatt capacity sufficient to enable them to use all the water normally available for short-period operation at times of peak load.

(3) Thermal stations, either remote from or near load centres, but having cheap fuel supplies, are designed for base load operation.

(4) Thermal stations near load centres where fuel is expensive are designed for and operated for peak load supply only.

It has not yet been necessary to consider the building of thermal stations on sites remote from load centres where fuel is also expensive.

Water and Fuel Storage.—In the case of thermal stations, stocks of coal are built up during the summer and drawn on in winter to maintain supplies to the plant despite irregularities in the flow of fuel from the pits. Stocking capacity is provided at new stations for about 25 per cent of the annual consumption.

In the case of the hydro stations, the allied problem arises of providing reservoir capacity. Several factors determine how much should be provided. In Scotland, rainfall is well spread over the year with more in the winter than in the summer six months. In an average year, the

TABLE II—*Monthly Distribution of Rainfall and Run-Off in Scotland*

	Rainfall percentage of annual	Run-off percentage of annual
October	10·5	11·0
November	10·5	11·5
December...	12·5	13·5
January	11·0	12·0
February	9·5	10·0
March	7·0	7·5
	61·0	65·5
April	8·5	8·5
May	4·0	3·5
June...	5·0	3·5
July	5·5	4·0
August	7·0	6·0
September	9·0	9·0
	39·0	34·5
Percentage	100	100

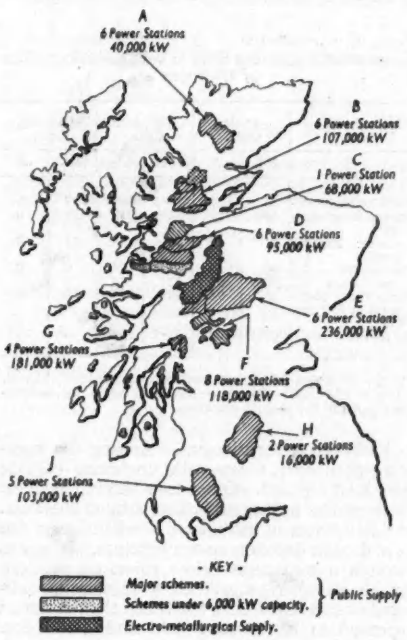
run-off for the winter six months is about two-thirds and for the summer six months one-third of the annual average. This is illustrated in Table II.

Annual variations in rainfall are not severe, the precipitation in an exceptionally dry year being about two-thirds and in a very wet one about one and a half times the long-term average. It is only in exceptional cases that the geological and other conditions in Scotland are favourable for the large-scale reservoirs which would be necessary to equalise annual variations. The reservoirs being constructed do, however, provide for adjustment of the seasonal variations.

The storage provided at each side has, in general, been decided by local geological conditions and, as a minimum, is sufficient to ensure that, in a dry year, water will be available so that the hydro plant will always meet its daily minimum allotted quota of kilowatts and kilowatt-hours.

Values for the storage and average annual output of a selection of schemes in operation and under construction are shown in the table reproduced with Fig. 1.

Generally speaking, stations nearer the load centres, designed for peak or day load operation with kilowatt capacity relatively high in relation to the annual output, can operate satisfactorily with limited storage. With such limited storage, it is not always possible to store sudden extraordinary flows. When extraordinary flows occur at such stations, most of the additional energy



Storage capacities of groups of schemes

Name of group	Ref. letter on Map	Storage capacity	Average annual output of associated stations	Storage / Output × 100
		Million kWh	Million kWh	Per cent
Garry-Moriston	*D*	200	370	54·1
Conon	*B*	132	440	30·0
Shin...	*A*	57·5	150	38·3
Affric	*C*	75	230	32·6
Tummel	*E*	153	600	25·5
Breadalbane ...	*F*	87	385	22·6
Sloy...	*G*	38	220	17·3
Galloway ...	*J*	36	224	16·1
Clyde	*H*	—	80	—

Fig. 1—Scottish hydro-electric schemes

available can be converted into electricity by prolonged running of the plant at full load during off-peak periods. On occasion, such so-called peak load hydro stations have been run continuously at maximum output for periods of a week to ten days to make full use of flood water. The existence of an adequate interconnecting grid facilitates operations of this nature. It is a simple matter, under such conditions, to shut down the less economical steam plant in order to absorb the additional kilowatt-hours available from hydro sources.

It is an advantage to arrange in terms of seasonal variation for the maximum amount of storage for stations with kilowatt capacity relatively low in relation to the annual output by providing, where reservoir sites are sufficiently favourable, storage in excess of the possible seasonal deficiency. Such capacity may indirectly provide a reserve against unfore-seen annual deficits at other schemes with limited storage.

Special Features of North of Scotland Hydro Generation.—The positions of the catchments now in process of development are shown in Fig. 1. This area possesses mountain ranges with general elevations of 2000ft to over 3000ft above the sea, good rainfall with intensities varying from 150in in the Western to 50in per annum in the Eastern Highlands, and a temperate climate with no prolonged frosts and low evaporation losses.

Geologically, it is also suitable for water power development. Impervious rocks mostly underlie its river basins and provide watertight floors for reservoirs. Individual catchment areas are small so that Scottish schemes are characterised by the employment of elaborate networks of collecting aqueducts and demonstrate how a small country's water power resources can be intensively and economically developed. The cost of the collecting aqueducts is balanced against the value of the extra output.

Almost all Scottish hydro schemes have to provide for the preservation of migrating fish, principally salmon. This has important effects on their selection and design. Facilities with sufficient flows of water are needed to enable salmon to ascend and descend all old as well as new obstacles to their movements and screens are required to prevent them entering the works. The amount of water set aside to ensure the movement and survival of fish life is a significant proportion of the available resources from a watershed. It may vary from 5 to 15 per cent or even more depending on the size and importance of the river. Moreover, to maintain minimum flows in rivers, certain stations are required to run continuously.

(To be continued)

Mechanisation of Quarries

THE report of H.M. Inspectors of Mines and Quarries for the year 1952 has been published this week by H.M. Stationery Office. It is a report to the Minister of Fuel and Power which is required under the Metalliferous Mines Regulation Acts and the Quarries Act. In the section dealing with quarries, the report records that the number of people employed during 1952 was 62,038, including 8360 employed at opencast coal workings. The total output of mineral was 160,385,200 tons, including 12,167,100 tons of coal and 226,500 tons of fireclay at opencast coal sites. The report says that mechanisation of quarries continues unabated wherever the nature of the mineral and overburden permits, and " a machine for the job " is now the aim. This increasing mechanisation, however, has introduced a new set of circumstances and risks which, the report observes, are not always appreciated either by workers or management. The new problems, including training, which are involved in the extensive use of portable machines of all kinds, demand extra care by all concerned. Such fast-moving machines as lorries and dumpers, the report continues, require careful handling, and it is urged that the transport systems inside and outside a quarry should be put on a proper basis in order to eliminate the undesirable factors which are often found to obtain when an accident occurs. The present position gives rise to much concern, the report remarks, as the accident rate connected with the haulage and transport of material continues to increase. The use of electric power for fixed and portable apparatus in quarries continues to increase, and about this the report says that much time, trouble and money would be saved if, before proceeding with new installations, the requirements of the Quarries General Regulations (Electricity), 1938, were carefully considered. It must be a matter of dismay to owners and managements, the report comments, to find that a completely new installation does not comply in all respects with the provisions of those regulations.

" ISO-PENTANE " PLANT.—A plant to produce " iso-pentane," an important constituent of aviation petrol, is now under construction at the Stanlow refinery of the Shell Petroleum Company, Ltd. The de-iso-pentaniser, which is a column 200ft in height and containing 140 turbo-grid trays, will receive two streams via steam heaters. One stream will be the pentane fraction from a depentaniser, and the other debutanised straight run gasoline, and the column will produce iso-pentane as the overhead stream. The bottom product, de-iso-pentanised straight run gasoline plus the normal pentanes from the platformate, will be blended into motor spirit.

Metallurgical Topics

Hydrogen Embrittlement

HYDROGEN, introduced into steel either by pickling or by electrolysis, results in a reduced capacity for deformation, a lowering of ductility as measured by reduction of area in the tensile test, and a fall in the true breaking stress. A leading investigator of this subject is Dr. P. Bastien, who, in conjunction with P. Azou,[1] some years ago, carried out an investigation which revealed a curious effect of very low temperatures on the properties of steel charged with hydrogen.

EFFECT OF SUB-ZERO TEMPERATURES

A 0·15 per cent carbon steel was subjected to acid attack (pickling) in 10 per cent hydrochloric acid solution, and was also cathodically charged with hydrogen in the same solution, after which tensile tests were carried out with the results shown in Table I. The effect of the hydrogen on true breaking stress and on reduction of area was evident at room temperature and at −70 deg. Cent., but at −180 deg. Cent. these properties were unaffected by the presence of hydrogen. At room temperature hydrogen is slowly evolved from the steel and the brittleness may gradually become less evident; and a short time at 100 deg. to 150 deg. Cent. may eliminate the hydrogen and so remove its embrittling effect. At −180 deg. Cent. the specimens showed no sign of brittleness in the tensile test. This was not due to the disappearance of the gas, since on allowing the temperature of the material to rise to −110 deg. Cent. and above the same indications of brittleness as were shown in the tests at −70 deg. Cent. began to appear.

TABLE I—*Tensile Tests on 0·15 Per Cent Carbon Steel Charged with Hydrogen*

Temperature of test	+18 deg. Cent.		−70 deg. Cent.		−180 deg. Cent.	
	T	*RA*	*T*	*RA*	*T*	*RA*
Not charged	105·5	74	107	69	129	48
Charged by attack of acid	79	56	75·5	37·5	129·5	47
Charged electrolytically	79	58	73	39	129	48

T=True stress at fracture in kilograms per square millimetre
RA=Reduction of area per cent.

The effect must be considered in relation to the observed fact that the notched-bar impact value of a steel is very little affected, if at all, by cathodically charging the test piece with hydrogen; that rapid application of stress in a tensile test masks the effect; but that the most marked manifestation of the embrittlement is obtained by slow loading of the tensile test piece. The embrittling effect of hydrogen only becomes apparent if time is allowed for diffusion of the atomic hydrogen in solution to take place and so allow the hydrogen to accumulate in the insoluble molecular form under pressure at imperfections or discontinuities in the structure of the steel. At a temperature of −180 deg. Cent. the rate of diffusion of hydrogen was presumably too low to permit of a sufficient accumulation of molecular hydrogen to induce embrittling triaxial stresses. The reversibility of the effect above and below a temperature of about −110 deg. Cent. appears to be the result of the change in a rate of diffusion of hydrogen with change in temperature.

EFFECT OF MICROSTRUCTURE

This work has been followed up by P. Bastien and P. Amiot[2] who have reported the results of an investigation of the effect of the microstructure of the steel on embrittlement by hydrogen. A chromium-molybdenum steel was chosen for the experiments because, by suitable heat treatment, such a steel can be made to show all the structures obtainable in a ferritic steel. The steel with each of the structures investigated was electrolytically charged under conditions which always gave about the same hydrogen content (2c.c. per 100g) and tensile tests were carried out. As the property most affected is reduction of area, the investigators chose an index of susceptibility of the microstructure to the effect of hydrogen having the form :—

$$S=100(RA_n-RA_c)/RA_n$$

where RA_n=percentage reduction of area of the specimen, not charged, and RA_c=percentage reduction of area of the specimen charged with hydrogen, both tests being carried out at the same temperature. Typical results are given in Table II.

The microstructures which are most ductile, as shown by reduction of area, are least sensitive to hydrogen embrittlement. Among the pearlitic specimens, those with coalesced carbide were least affected. Other tests showed that the same applied to the sorbites containing coalesced or finely dispersed carbides. The brittleness due to hydrogen depends on temperature. It passes through a maximum below room temperature for all microstructures except martensite tempered at 550 deg. Cent., for which the maximum appeared to be between +15 and +100 deg. Cent. As already found in the previous investigations referred to above, the brittleness due to hydrogen had disappeared from all specimens, irrespective of microstructure, at the temperature of liquid nitrogen (−196 deg. Cent.) but reappeared when the temperature had risen above −110 deg. Cent.

TABLE II—*Sensitivity of Different Structures in a Chromium-Molybdenum Steel to the Embrittling Effect of Hydrogen*

Temperature of test	+15 deg. Cent.		−80 deg. Cent.		−196 deg. Cent.	
	RA_n	*S*	RA_n	*S*	RA_n	*S*
Globular pearlite ...	76	31	70·5	66	57	0
Fine lamellar pearlite	66	39	62	50	21	0
Coarse lamellar pearlite	62·5	42	56	56	15	0
Fine bainite	60	56	57	67	9	0
Coarse bainite ...	38·5	93	42	94	3	0
Martensite tempered at 550 deg. Cent.	63	94	60	87	60	0
Martensite	47·5	100	35·5	100	—	—

RA_n=Reduction of area per cent of specimens not charged. The sensitivity, $S=100\ (RA_n-RA_c)/RA_n$ where RA_c=reduction of area of the charged specimen.

REFERENCES

[1] *Comptes Rendus*, 1949, Vol. 228, pages 1337 and 1651; Vol. 299, page 549
[2] *Comptes Rendus*, June 9, 1954, Vol. 238, page 2238.

Intergranular Fracture at Raised Temperatures

IT is well known that pure metals and certain metallic solid solutions, when stressed at raised temperatures, break with an intergranular fracture and show little ductility. The change from transcrystalline to intercrystalline fracture with increase in temperature was formerly explained by the simple conception of an "equicohesive temperature" at which grains and grain boundaries were equally resistant to stress. On account of the viscous behaviour of the grain boundary, the equicohesive temperature varied with the rate of application of stress. Below the equicohesive temperature the grain boundaries were thought to be resistant to stresses which caused slip to take place within the crystal grains, and above it grain boundaries were weaker than the grains. It has long been evident that this was an oversimplification of the facts, and some work carried out at the University of Melbourne throws further light on the mechanism of the process leading to intergranular failure at raised temperatures.*

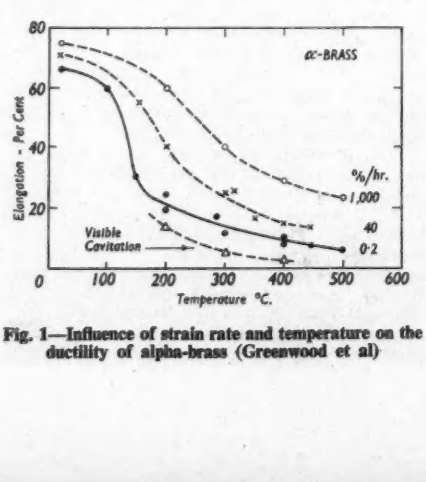


Fig. 1—Influence of strain rate and temperature on the ductility of alpha-brass (Greenwood et al)

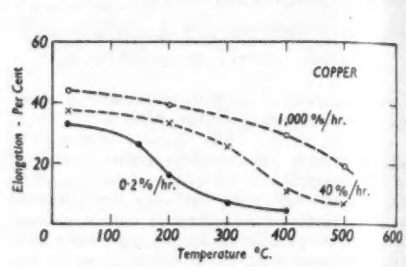


Fig. 2—Influence of strain rate and temperature on the ductility of copper (Greenwood et al.).

It has been found that, when copper, α-brass and magnesium are strained at elevated temperatures cavities appear in the intercrystalline boundaries. These were more prevalent in the boundaries lying transversely to the direction of the applied tensile stress. This intergranular cavitation is visible under the microscope and is accompanied by loss of ductility as shown by the elongation at fracture. For any temperature the loss is greater the lower the strain rate, and for a given strain rate the loss is greater the higher the temperature. Microscopical examination showed that the cavities appeared at regular intervals along the grain boundaries, and under tensile stress they linked up to form intercrystalline cracks.

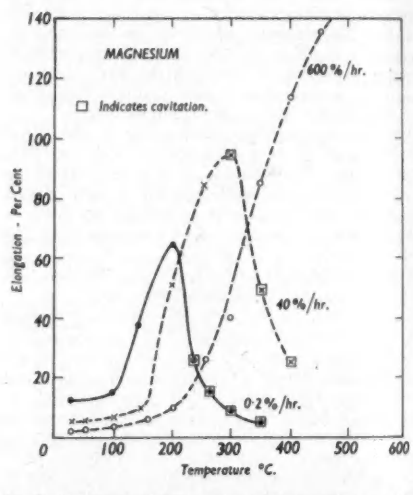


Fig. 3—Influence of strain rate and temperature on the ductility of magnesium (Greenwood et al.).

The behaviour of α-brass (copper 70·1, zinc 29·8 per cent) is shown in Fig. 1. Ductility falls off rapidly as the temperature rises and for any

* J. N. Greenwood, D. R. Miller and J. W. Suiter: "Intergranular Cavitation in Stressed Metals," *Acta Metallurgica*, March, 1954, Vol. 2, page 250.

given temperature is lower the lower the rate of strain. Microscopical examination of specimens at various stages of the experiments showed that no cavitation was visible below 250 deg. Cent. when the rate of strain was 1000 per cent per hour, below 200 deg. Cent. when the rate of strain was 40 per cent per hour, or below 150 deg. Cent. when the rate of strain was 0·2 per cent per hour. With a rate of strain of 0·2 per cent per hour cavitation began to occur above 14 per cent and below 17 per cent extension at 200 deg. Cent. (elongation at fracture 20 per cent), above 3 per cent and below 5 per cent extension at 300 deg. Cent. (elongation at fracture 11 per cent), and below 1·5 per cent extension at 400 deg. Cent. (elongation at fracture 6 per cent). Oxygen-free high-conductivity copper behaved like α-brass when strained at raised temperatures (Fig. 2). The extent of cavitation increased rapidly with temperature, and this increase was coincident with a change in the mechanism of deformation, coarse slip giving place to grain translation. In this connection it may be recalled that a chain of cavities was observed by N. D. Benson and others† in the intercrystalline boundaries of tough pitch copper which broke in 10,000 hours with only 1·5 per cent elongation.

The behaviour of magnesium, which contained 0·2 per cent of lead in solid solution and 0·02 per cent of iron, was interesting. The elongation, at first low, increased after a temperature of 125 deg. to 250 deg. Cent. was exceeded and rose to a maximum, the actual relation depending on the rate of strain (Fig. 3). Magnesium behaves like copper and α-brass in that cavitation occurs at a lower temperature the lower the rate of strain. The rapid rise in elongation at slightly elevated temperatures is due to a change of slip mechanism from the basal (hexagonal) plane to the pyramidal set of planes of which more than one may be operative. The new planes come into operation at a lower temperature the lower the rate of strain. The fall from maximum elongation coincides with the appearance of cavitation in the grain boundaries.

The authors of the paper claim that their observations are consistent with the suggestion that the cavities nucleate by the agglomeration of a sufficient number of vacant lattice sites to form a stable "hole." These cavities then grow, partly by the absorption of more vacant sites and partly by stress concentration at the periphery, so that if straining is continued after cavitation has started the cavities ultimately join up to form continuous cracks leading to intergranular fracture.

Work Hardening of Mild Steel Under Explosive Impact

SOME time ago, J. S. Rinehart[1] observed that, when a layer of explosive was detonated on the surface of a metal plate, the work hardening undergone by mild steel was different in character from that in copper, brass or an aluminium

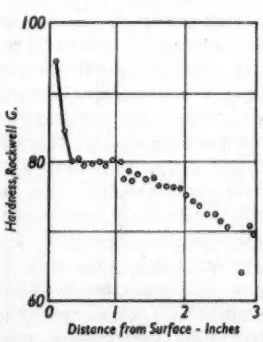


Fig. 1—Hardness across section of a mild steel plate, on the surface of which an explosive had been detonated (Rinehart)

alloy. The hardness determined at various depths from the surface of plates of these materials fell gradually and the hardness curves showed no abrupt changes of slope. On the other hand, in mild steel the hardness first decreased rapidly with increasing distance from the surface at which the explosive was detonated; it then remained constant for a considerable distance and beyond this fell more or less gradually to the initial hardness of the plate (Fig. 1). As a result of microscopical examination, which revealed a large number of Neumann bands in the region of constant hardness, Rinehart concluded that normal plastic deformation by slip was superimposed on mechanical twinning in a

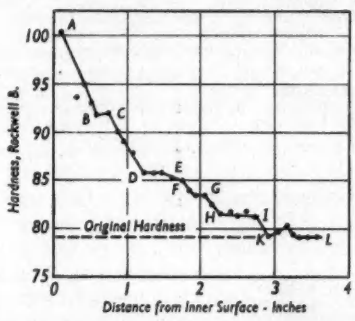


Fig. 2—Hardness across wall thickness of a thick-walled mild steel cylinder internally loaded with explosive (Pearson and Rinehart). Cylinder 9in outside diameter, 1in inside diameter and 6in long

narrow region close to the explosive, but that mechanical twinning (shown by Neumann bands in the microstructure) was mainly responsible for the work hardening throughout the rest of the plate. Later, examination of fragments of a mild steel cylinder, which had been burst by an explosive charge, appeared to indicate a discontinuous hardening effect over the cross section, or a series of plateaus in the hardness curve from the inner to the outer surface.[2]

This evidence, however, was gathered from separate fragments. In their later work, J. Pearson and J. S. Rinehart[3] arranged conditions so that the cylinder should suffer permanent deformation, and possibly internal fracture, as a result of the explosion, but should not fragment. Examination of a circular cross section of the cylinder then afforded a comprehensive picture of the work hardening undergone by the steel from its inner to its outer surface. Hardness tests were made along the radius of the cross section. While actual values of hardness differed along different radii, the general features were the same. A typical hardness curve is shown in Fig. 2. In the region *AB* visible grain flow had

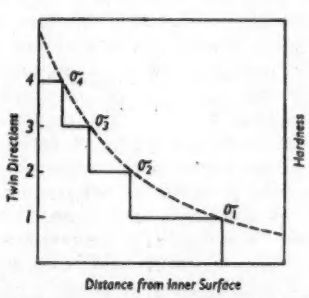


Fig. 3—Idealised curve of hardness supposed to result solely from mechanical twinning

occurred. Neumann bands were present throughout the remainder of the cylinder wall wherever work hardening had occurred. The abundance of twins decreased with increase in distance from the inner surface. Near the inner surface (in the region *AB*) the appearance of twinning had been obliterated by superimposed plastic deformation. The maximum number of twin directions found on the etched surface of a single ferrite grain was four, and the maximum number found on any single grain decreased with increasing distance from the inner surface, becoming one less in the region of each successive plateau. Thus the regions *BC*, *DE*, *FG* and *HI* were characterised by a maximum number of twin directions in a single ferrite crystal of 4, 3, 2 and 1 respectively. This gave a clue to the cause of the abrupt changes in hardness. There is evidence that a critical shear stress is required to produce mechanical twinning in ferrite. The shear stress at any position in the wall thickness is related to the radial stress. At a relatively low stress, σ_1 twinning might be expected to occur on the most favourably oriented set of twinning planes only. With progressively higher values of the stress, σ_2, σ_3, σ_4, the second, third and fourth set of planes would come successively into operation. The distribution of radial stress is represented by a smooth curve (Fig. 3) but the fact that only the successive stresses σ_1, σ_2, σ_3 and σ_4 cause increases in mechanical twinning tends to give a distinct step pattern to the work hardening undergone; though the random orientation of crystals and the occurrence of deformation other than by twinning will tend to smooth out the idealised curve in Fig. 3, and might result in a hardness curve similar to that in Fig. 2.

It therefore appears that the work hardening of mild steel under explosive impact is primarily due to mechanical twinning of the ferrite shown by the formation of Neumann bands. This explanation is based on microscopical examination; it accounts for the occurrence in the hardness curves of plateaus peculiar to mild steel and not shared by copper and other metals which do not form mechanical twins, and the work hardening curves of which are smooth and show no abrupt change of direction.

REFERENCES

[1] *Journal Appl. Physics*, 1951, Vol. 22, page 1086; THE ENGINEER, October 26, 1951, page 526.
[2] *Journal Appl. Physics*, 1952, Vol. 23, pages 434 and 685.
[3] *Journal Appl. Physics*, June 1954, Vol. 25, page 778.

Red Shortness in Iron-Carbon Alloys

ANOTHER instalment of the U.S. Bureau of Mines investigation of the effect of various elements on the red shortness of steel has been published. The first paper[1] dealt with the effect of sulphur, the main conclusion being that whereas pure iron-carbon alloys with only 0·002 per cent of sulphur had excellent hot-working properties, these deteriorated with increasing sulphur content, becoming poor at 0·01 per cent, until with 0·017 per cent sulphur the alloy could not be hot forged. The paper now published deals with the combined effect of sulphur and manganese.[2] The tests, carried out in a similar way to the previous tests, were made on alloys containing 0·15 to 0·28 per cent of carbon, thoroughly deoxidised with aluminium, the residual aluminium content being 0·06 to 0·08 per cent. The limit of hot forgeability is given in the form of the equation:

Percentage $Mn = 1{\cdot}25$ (percentage S) $+ 0{\cdot}03$.

The paper merely states this conclusion and contains no theoretical discussion of the results. It may, however, be noted that the Mn/S ratio in MnS is 1·7, and that the formula gives a ratio exceeding this up to 0·06 per cent sulphur. It would be misleading to assess the manganese required in practice on this formula, referring as it does to pure deoxidised material. In work carried out at the U.S. Bureau of Standards thirty years ago[3] it was found that manganese may prevent red shortness in iron when present to the extent of three times the sulphur percentage, if the oxygen content is not over 0·04 per cent; but that the presence of considerable amounts of oxygen in iron tended to reduce the efficiency of manganese in preventing red shortness. Hence, the fact that recommended ratios of manganese to sulphur, to overcome red shortness, range from 3 to 6, or even 8, depending on the kind of iron or steel and the manner in which it is to be processed. Moreover, in specifying a minimum manganese content (except for wrought iron and certain free-cutting steels), provision for a suitable manganese/carbon ratio is sufficient to guarantee an adequate manganese/sulphur ratio.

REFERENCES

[1] *Journal of Metals*, April, 1953, page 525; THE ENGINEER, June 26, 1953, page 895.
[2] *Journal of Metals*, July, 1954, page 835.
[3] U.S. Bureau of Standards, *Technological Paper*, No. 261, 1924

† *Jour. Inst. Metals*, 1951, Vol. 80, page 131.

THE ENGINEER

Vol. 198 JULY 30, 1954 No. 5140

LEADING ARTICLES—
An Encouraging Degree of Unanimity 162
Refuse, Sludge and Compost in Agriculture ... 162

ARTICLES—
Air Compressor Set for Technical College. (Illus.) 173
Determination of Economic Steam Cycle for Nuclear Power Station. No. II. (Illus.) 148
Duty-Free Machinery 145
Explosion Characteristics of a Lubricating Oil Mist. (Illus.) 165
Fuel Research Report 172
Geared Motor Units. (Illus.) 170
Integration of Hydro and Thermal Generation in Great Britain. No. I. (Illus.) 158
Mechanical Engineering Research, 1953 172
Mechanisation of Quarries 159
Plants for the Production of Anti-Knock Compounds. No. II. (Illus.) 151
Proposed Bridge Over the Mersey 145
Ring Rolling Machine. (Illus.) 170
Rye House Generating Station. (Illus.) 155
Shaft Sinking Accidents, 1905–1952 165
Small Air-Cooled Diesel Engine. (Illus.) ... 158
Some Notes on the Development of Fairground Machinery. No. III. (Illus.) 146
Standards and Exports 145
Submarine Pipeline. (Illus.) 173
Technical Interpreter 171
Tubular Speedboat Hull. (Illus.) 174
Ultrasonic Cleaning Plant. (Illus.) 174
Watford Derailment Inquiry Report 145
World Power Conference, Rio de Janeiro ... 145
3030 H.P. Electric Locomotives for South African Railways. (Illus.) 168

AMERICAN SCENE—
Rotary Metal Forming Process. (Illus.) 175
Large Intermittent Wind Tunnel 175
Fabrication of Pressure Vessels. (Illus.) 176

METALLURGICAL TOPICS—
Hydrogen Embrittlement 160
Intergranular Fracture at Raised Temperatures. (Illus.) 160
Work Hardening of Mild Steel Under Explosive Impact. (Illus.) 161
Red Shortness in Iron-Carbon Alloys 161

LETTERS TO THE EDITOR—
Qualifications for Special Library Work 164

LITERATURE 164

OBITUARY—
Sir Herbert Williams, Bart. 163
P. H. Wilson 163
J. L. Adam, C.B.E. 163
William G. Riddell 164

NEWS AND NOTES—
British Patent Specifications. (Illus.) 179
Catalogues 180
Forthcoming Engagements 180
Industrial and Labour Notes 177
Launches and Trial Trips 178
Notes and Memoranda 178
Personal and Business 178
Technical Reports 180

AN ENCOURAGING DEGREE OF UNANIMITY

Usually, when technological education is a subject for discussion, about as many views are expressed as there are people ready to take part in the talking. The most remarkable thing about the "Memorandum on Higher Technological Education" published by the Parliamentary and Scientific Committee last Monday is, therefore, that "after receiving oral evidence from a number of distinguished experts" and ascertaining the views "of a wide range of learned societies and institutions," the Committee was able to find "a most encouraging degree of unanimity" amongst them. After reviewing the need within this country to provide facilities for training many more technologists than at present—a need very widely admitted and additionally stressed by the demands of industry for men with technological training; after studying what the universities have done and are doing to extend capacity, condemning on the way "the arbitrary dictum of the Barlow Committee that the number of art students . . . should be doubled as well as the number of science students"; and after suggesting further expansion of university post-graduate facilities, the Memorandum outlines a scheme for technological education under which a few colleges of technology would be selected and granted a Royal Charter under which they would be described as Royal Chartered Colleges of Technology.

The Committee has a clear picture of what these Chartered Colleges should be like. "They should provide for an advanced full-time sandwich, and part-time day and evening courses, post-graduate courses, and research on a full-time and part-time basis. It is also desirable that the colleges which are selected . . . should associate their advanced work with research and should be capable of preparing students for higher degrees." They will also be expected "to build up their own scientific and technological education schemes and thus earn a reputation for themselves in particular sciences and technologies." Their courses, it is quite clear, are intended to reach a standard equivalent to that of a degree course, but, no doubt, different in content and biased towards particular technologies. Lower grade day and evening technical and technological students, no doubt those with insufficient entry qualifications, would be excluded from those specially selected colleges but catered for amongst colleges not selected for this particular treatment, technical schools, &c. The Committee takes a commonsense view of the question which has, unfortunately, often bedevilled the discussion of technological education, the title of the award to be offered by a technological college. What's in a name? Sensibly the Committee remarks "If the proposed Royal Chartered Colleges of Technology developed a high standard of teaching the men they produce would enjoy a high prestige amongst all employers whatever letters they might be entitled to put after their names." But the preference is for the award of Bachelor of Technology, a title to which universities might object on the grounds of confusion with a university degree. The Committee also does not fail to notice the need for co-ordination as between the Colleges and suggests the creation of a Council of Royal Chartered Colleges whose main purpose would be to agree upon the lengths and standards of courses for awards, but which would leave examinations and actual awards to the Colleges themselves.

We can hardly doubt from what the Committee says in its Memorandum that even a wider appeal to individuals and institutions than the Committee was able to make would still show "a most encouraging degree of unanimity" of approval of the principle of this scheme. But how far, we wonder, would that approval extend to detail? Clearly enough, ideas about higher technological education are unifying upon the principle that only a few technological colleges should be chosen to undertake it. But is there yet any unity of view as to whether those few colleges should make their own awards (the title of which it is so difficult to decide upon) or whether they should be closely linked to universities so that those universities would make the awards, which would then be, of course, degrees, doctorates, &c.? Lack of unity in that sense, however, does not affect the nature or the quality of the courses to be presented, upon which all parties seem agreed; would not influence the number of colleges to be selected, though there might be disagreement about the inclusion or exclusion of particular colleges; and could have little bearing upon the nature of governing bodies which, it seems to be agreed, ought to be granted as much academic freedom as possible. The existence of this disunity is, therefore, far less important than might be supposed at first sight. What does occur to us, in our role of commentators upon views and events, is that, since it is intended that awards given by the Colleges are to rank as parallel in worth with university degrees, close linkage of the selected colleges with universities would get round the vexatious trouble of deciding upon the title of the awards. Furthermore, if that close linkage were adopted there would be no need to set up any special Council to co-ordinate the work of the selected colleges. Nor is there anything revolutionary in suggesting the development of so close a linkage. In the ordinary course of evolution colleges in the past have been absorbed into universities. The only alteration from that line of evolution here contemplated is that the selected Technological Colleges, instead of adopting courses laid down by the universities with which they were associated would develop their own courses, deliberately biased to particular technologies, for approval by those universities. Very possibly it is this plan of development that the Government has in mind.

REFUSE, SLUDGE AND COMPOST IN AGRICULTURE

Ever since the water carriage of sewage and the collection by local authorities of towns' refuse became essential to the health of cities it has been argued that man's failure to return these wastes to the soil has been reducing the fertility of the land and that by disposing of these materials in other ways man is wasting a valuable material. More lately the virtues of composting sewage products with towns' refuse have been much canvassed and it has been held that in this form an excellent fertiliser can be made economically. Recently the Natural Resources (Technical) Committee set up in 1950 under the chairmanship of Professor Zuckerman to advise the Lord President of the Council has been examining these arguments. That committee's reports are not usually published. In this instance, however, its findings and conclusions were published last week by the Stationery Office under the title "The Use of Towns' Wastes in Agriculture"; and we published its conclusions on page 109 of our last issue. The committee finds *inter alia* that "apart

from dried digested sludge and activated sludge the potentialities of towns' wastes in agriculture have often been over-estimated"; that in its opinion "there is no case for authorising the expenditure of public money on pilot plant experiments on methods of composting," and that "the manurial value of screened dust" from household refuse "is low and . . . its use for agriculture . . . uneconomic."

These conclusions are likely to prove decidedly dampening to enthusiasts, particularly the protagonists of composting. However, upon examination, the report proves to be less exhaustive in its survey of the subject than at first appears. That is a remark more particularly true about composting. The report does, indeed, bring out how relatively little compost could be made. The supplies of sewage sludge not already applied to land amount annually to some 400,000 tons of dry matter. If the whole of the organic matter from the available household refuse in England and Wales were composted it could not absorb more than 100,000 tons out of that amount. The compost would contain about 4500 tons of nitrogen. That latter figure should be compared with 210,000 tons of nitrogen applied to the land in 1953 in the form of fertiliser. The report also reveals clearly that as a source of humus forming material compost would not add very largely to supplies already available. But it fails to examine claims made that compost contains important trace elements in forms easily assimilable by plants; it does not discuss whether compost may have a special value when applied to soils of a particular character (though it does admit that it "has value" in horticulture); and it has nothing to say on the possibility that the process might prove more economic abroad than at home owing to the particular nature of the soils, higher cost of fertilisers, &c., a situation which might justify pilot plant experiments at home to obtain experience from which consultants could benefit. But perhaps the members of the committee had it in mind that the fully mechanised plant being set up at St. Helier in Jersey will provide all the information that a pilot plant could be expected to reveal.

Turning to the more direct use of waste materials the report finds that little is to be expected of screened refuse dust from household refuse: and that "the quantities of nutrients and humus-producing materials which would be made available by the full agricultural utilisation of our towns' wastes are small compared with those applied each year as fertiliser and contributed by normal farming practice." If household refuse is excluded and only such sewage sludge as is already produced comes under consideration the remark is true enough. Of 750,000 tons of dried sewage sludge per annum thus produced nearly a half is already used on the land and the remaining 400,000 tons would provide only 10,000 tons of nitrogen and 5000 tons of phosphoric acid as compared with 210,000 tons of nitrogen and 400,000 tons of phosphoric acid available from fertilisers. But that calculation neglects the sludge available if certain untreated effluents, now poured directly into estuaries such as the Tyne and Thames to the great detriment of amenities, public health, inland fisheries and other things, were purified. It also neglects the fact that as much as 60,000 tons per year of nitrogen and between 8000 and 10,000 tons per year of phosphoric acid are potentially recoverable from liquid effluents. A recent Dutch estimate, mentioned in the report, claims that as much as 70 per cent of this nitrogen can be recovered. Even compared with the 210,000 tons of nitrogen per year applied to the land as fertiliser that is a significant figure. When it is remembered that its recovery would also contribute to the reduction of water pollution —a point that seems to have escaped notice in the report—the conclusion of the committee that "attention should be given to the investigation of methods of sewage treatment whereby part of this nitrogen might be recovered" is very welcome. We hope it will be followed up. It seems to us, too, as it seems to the committee, that "an estimate of the cost of nitrogen recovery from sewage compared with that of producing nitrogenous fertilisers by conventional methods would be useful." Incidentally, those conclusions conflict utterly with a categorical sentence on another page of the report that the nitrogen in the effluent discharged to rivers "could not be recovered economically"! We cannot say that we regard this report as exhaustive; we regard some of its conclusions as open to critical debate. But at least it serves to put the whole matter into perspective. In particular, the examination of soil fertility that the committee was able to make gives no support to those who maintain that by failure to return towns' wastes to agriculture the fertility of the land is being reduced.

Obituary

SIR HERBERT WILLIAMS, BART.

ENGINEERS will have learned with regret of the death of Sir Herbert Geraint Williams, Bart., which occurred on Sunday last, July 25th, for although in recent years he had devoted most of this time to political affairs, he was by training and profession an engineer. Sir Herbert, who was sixty-nine, was born at Hooton, Cheshire, and was educated privately and at Liverpool University, where he graduated in 1906. Subsequently, he gained the degrees of M.Sc. and M. Eng. He served an apprenticeship in the dynamo works of Siemens Brothers, at Stafford, and was then engaged in marine work in the consulting practice of Mr. L. A. Smart, and later in electrical engineering work with Sir John Norton Griffiths. From 1911 to 1928 Sir Herbert was secretary and manager of the Machine Tool Trades Association, and was then, for some years, director of the Empire Industries Association. He was also for a time the executive director of the Incorporated Association of Electric Power Companies. In the first world war Sir Herbert was secretary of the machine tool department of the Ministry of Munitions.

Sir Herbert entered Parliament in 1924, and from 1928 till 1929 he was Parliamentary Secretary to the Board of Trade. In February, 1932, he was returned as Member for South Croydon, which seat he held until the General Election of 1945. From 1939 to 1944 Sir Herbert was a member of the Select Committee on National Expenditure. He returned to Parliament in 1950 as member for East Croydon, which constituency he represented at the time of his death. Sir Herbert was the author of several books and pamphlets on economic and political matters, in most of which he forcefully advocated tariff reform. He received a Knighthood in 1939 and was created a Baronet last year.

P. H. WILSON

WE regret to have to record the death of Mr. Percy Hutchinson Wilson, M.I.Mech.E., deputy managing director of the Stanton Ironworks Company, Ltd., Nottingham, which occurred suddenly last Sunday, July 25th. Mr. Wilson had taken a prominent part in the foundry industry in this country for forty years or so, and will be particularly well remembered for his work in connection with the principle of centrifugal casting, and for the design and introduction of the flexible pipe joint which bears his name.

Percy Wilson served his apprenticeship partly with Whessoe Foundry Company, at Darlington, and partly with Markham and Co., Ltd., at Chesterfield. His earlier appointments included those of casting inspector for the Liverpool Corporation Waterworks at Widnes Foundry, and works superintendent of James Oakes and Co., Ltd., Alfreton. He joined the Staveley Coal and Iron Company, Ltd., as works manager and engineer in 1911 and eight years later he resigned that position to become foundry general manager of the Stanton Ironworks Company, Ltd. Mr. Wilson was appointed assistant managing director (technical) in 1940 and three years later became deputy managing director of the company. During the second world war he was largely responsible for the design, construction and operation of a plant for the mass production of steel bombs at the Erewash Foundry, and for his war service was awarded an O.B.E. in 1943.

For several years Mr. Wilson was actively associated with the work of the British Cast Iron Research Association. He was a member of the Institution of Mechanical Engineers, and a past-president of the Institute of British Foundrymen, which he joined in 1928. The Institute's E. J. Fox Gold Medal was awarded to him in 1942 in recognition of his distinguished services to the foundry industry.

J. L. ADAM, C.B.E.

ALL those engaged in shipbuilding will have learned with regret of the death of Mr. John Lockhead Adam, which occurred on July 22nd, at his home, "Reay Cottage," on Seil Island, by Oban. Mr. Adam, who was born in 1884, was educated at the Glasgow Academy and George Watson's College, Edinburgh, and served his apprenticeship as ship draughtsman with W. Henderson and Co., Ltd., Glasgow, from 1889 to 1905. During these years he received his technical education at the Glasgow and West of Scotland Technical College. In the following five years he gained experience with John Cran and Co. at Leith, and then spent a further two years with John I. Thornycroft and Co., Ltd., at Southampton. Towards the end of 1911 Mr. Adam was appointed a ship surveyor to the British Corporation, a post which he continued to hold, apart from a short period in the Army during the first world war, until 1918, when he was made Principal Surveyor at Glasgow. Nine years later he became assistant chief surveyor to the British Corporation and was appointed chief surveyor in 1940, upon the retirement of the late Dr. J. Foster King, C.B.E., a position which he continued to occupy until

he retired in 1949, when the British Corporation amalgamated with Lloyd's Register of Shipping.

Mr. Adam served on a number of Government committees, and his services to the Admiralty and the Ministry of War Transport during the second world war were recognised when he was made a C.B.E. He was always seeking to develop improved methods of ship construction and was one of the pioneers in the application of welding to ships and during his term as president of the Institute of Welding he was largely instrumental in establishing the International Institute of Welding. The *Transactions* of many technical societies contain many papers, read by Mr. Adam, upon subjects which were concerned mainly with the practical aspects of shipbuilding. John Lockhead Adam was elected a member of the Institution of Naval Architects in 1918, served on the council of that body, and after ten years as a vice-president became an honorary vice-president in 1952. He was also an honorary fellow of the North East Coast Institution of Engineers and Shipbuilders. His active life was concerned with ships and shipping, and he continued to serve these interests after his retirement, during which he interested himself in yachting and became the owner of an auxiliary yacht which he had designed and built.

WILLIAM G. RIDDELL, O.B.E.

IT is with regret that we have learned of the death of Mr. William George Riddell, which took place last week in Durban, South Africa, where he had lived for a number of years in retirement. Mr. Riddell was born near Jedburgh in 1871 and received his training in marine engineering with the Fairfield Engineering and Shipbuilding Company, Ltd. Shortly after completing his apprenticeship he went to sea as a junior engineer and in 1896 gained his chief engineer's certificate. The next two years he spent in the employment of his former company and then in 1898 joined David Rowan and Co., Ltd., as an under-manager. Three years later Mr. Riddell sailed for Finland upon his appointment as the manager of a shipbuilding and engineering works at Abo, and in 1903 he returned to the Clyde to occupy the post of joint managing director of John Hastie and Co., Ltd., of Greenock. When his co-director, the late Mr. Walter Graham, retired in 1918, Mr. Riddell became managing director and eventually chairman and continued in these positions until 1934, when he retired. Mr. Riddell was awarded the O.B.E. for his work at the Admiralty during the first world war, and he was also the author of two books entitled *Adventures of an Obscure Victorian* and *The Thankless Years*, which described the work of a Clyde engineer ashore and afloat.

Shaft Sinking Accidents 1905–52

IN an article by Ian C. Easton under the above heading in our issue of November 27, 1953, the author made reference (*inter alia*) to an accident which occurred at Point of Ayr Colliery, Flintshire, in 1952. That article was published without knowledge that legal proceedings had been begun arising out of that accident. In the circumstances, it is desirable to emphasise that statements about the cause of the accident appearing in the article were, of course, expressions only of the opinions of the author. These statements were based on such information as was then known to the author of the article. In particular, the article was written without any knowledge of the results of the detailed investigation carried out after the accident by the Contractors and the Consultants to the National Coal Board.

Literature

Minerals for the Chemical and Allied Industries. By SIDNEY J. JOHNSTONE. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 75s.

THE growth of technology has caused a demand, not only for a widening variety of mineral products, but for higher standards of quality. The manufacturing industries are not usually content to accept minerals in run-of-mine condition ; more and more they seek a product which has been selected or, if necessary, processed to meet the specific needs of their operations. The author, a former Principal of the Mineral Resources Department of the Imperial Institute, recognising this tendency, believes that the producer of minerals often finds difficulty in ascertaining the standards to which his output must conform if it is to be suitable for the uses for which he may hope to sell it. One of the author's principal tasks, therefore, has been to collect specifications from many sources (including U.S.A.) to serve as a guide both to producer and consumer by indicating current standards of quality. However, he rightly cautions the producer against concluding that a product not conforming to such specifications cannot be marketed. Mr. Johnstone also draws attention to the possibility that consumers could, in some cases, use less stringent specifications. There is no doubt in the reviewer's mind that specifications for chemical raw materials, at all events, are often drawn up with less regard for the practical requirements of their application than for some theoretical standard which the producer is expected to approach if he can.

More than seventy minerals are separately dealt with in alphabetical order in this work and the occurrence, extraction and uses of each are rather fully described. The author speaks with commendable restraint of the inadequacy of British statistics dealing with production and consumption of minerals. (There is a danger that we shall begin to regard this inadequacy with the same kind of tolerant amusement and affection which we accord to the English climate.) He therefore supplements these meagre data with American figures and is only rarely obliged to omit any kind of statistical perspective from his picture. Mr. Johnstone emphasises the importance of the physical form of minerals to the user and hence to the seller. This is naturally the case where the material is used for its physical properties, but it is a consequence of the growing complexity of the design of chemical plants that their raw materials have to conform more and more exactly to some standard physical condition which can best be handled. The author has wisely decided not to include information on prices, as these change so much and so often. The full bibliography for each material and the general one at the beginning of the book are valuable features.

There is certainly a need for a book such as Mr. Johnstone's, and the lack of it has hitherto been felt by many who are concerned with this field. He has tackled the task with immense industry and the care and knowledge drawn from a lifetime's experience. The result is admirable ; many will have cause for gratitude to the author. If one has any doubts, they concern the ability of any one individual to write authoritatively in all sectors of the vast area which the author has set out to cover. It may be that he has attempted to provide too much detail in the properties and uses of products derived from the mineral raw materials. Is it necessary, for example, to give the melting and boiling point of elemental fluorine in the article on fluorspar, or to say that "'Fluor' (sic) $(CF_2)_n$ is a substance which behaves like a plastic" or in the article on silica, that silicon tetrachloride melts at −67·8 deg. Cent.? In discussing the quality of lime to be used for calcium carbide manufacture, phosphorus is said to give rise to phosgene in the acetylene gas. It is doubtful whether much limestone is used in carbide furnaces (referred to as the "electrolytic" process for carbide), and it is not surprising that the "requirements for lime to be used in the manufacture of cyanamide are similar to those for carbide," since calcium cyanamide is made from calcium carbide. In the same article the boiling point of calcium metal is given as "about 1439 deg. Cent.," not a fact of great significance to the proprietor of a limestone quarry or to his customers. Chlorine is referred to as a by-product in making electrolytic caustic soda, but if either of these co-products could be called a by-product it is the alkali. In the article on gypsum and anhydrite, reference is made to the latter as a source of elemental sulphur ; this is premature. In the same article, "Solvay" Chemicals, Ltd., should read "Solway" Chemicals, Ltd. Much space is devoted to the composition of alloys, e.g. of titanium and nickel ; this has no strict relevance to the availability and quality of the ores. There is an article on calcium chloride because it occurs naturally, although, as the author says, industrial requirements are mostly met from by-product material, and wholly so in this country. This list could be prolonged, but it would be a pity if these minor blemishes were to have the effect of reducing confidence in the more essential parts of the book—those dealing with the properties of the minerals themselves. The price is high and it may therefore be fairly pointed out that the length of the book could have been reduced by more careful editing, and a more scrupulous arrangement of subject matter under headings could have eliminated several examples of repetition.

These criticisms are made in a constructive way so that when the time comes for a second edition—which will surely be welcome—they may point the way to improvement here and there. Perhaps the growing practice of assembling a group of specialists under an editor-in-chief will be adopted to secure authoritative treatment of some of the more highly specialised topics.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

QUALIFICATIONS FOR SPECIAL LIBRARY WORK

SIR,—I have read Mr. Kay's stimulating article on "Qualifications for Special Library Work" with great interest and I cannot help feeling that in it he has "hit the nail on the head" more decisively than in anything I have read for some time. I am one of the unfortunate army of nondescripts working in a special library who has to perform, on occasions, the duties listed under librarian, information officer and intelligence officer ; most of the work is in handling information contained in periodicals, transactions and security information in Government reports and memoranda.

The Library Association Syllabus was studied by my organisation and as so much of it covered work which was outside our normal sphere of activity the matter was not pursued, but from the list of recommended books the pertinent ones were studied and the usefulness and efficiency of the organisation was increased. I have, however, attended several Aslib courses and these have been extremely valuable in confirming my own

ideas on Special Library and information work. I feel Aslib should be congratulated on its junior and senior courses, but as these do not lead to any qualification many people tend to regard them with less prestige than they deserve.

Mr. Kay states that discussion on qualifications are being held between Aslib and the Library Association and I hope that something concrete will emerge. I feel, however, if co-operation between the two associations proves impossible Aslib should go ahead with its own qualification and Association of Information Officers, and I am certain there would be considerable support for such an association.

BASIL C. DODGE

Bath, July 26th.

SIR,—I look forward to the comments which will surely be forthcoming, following upon Mr. Kay's excellent article in last week's issue.

A good deal of nonsense is talked when special library qualification crops up. Mr. Kay rightly hits the nail full squarely, too, when taking the L.A. to task for their apathy in catering for this large body of specialists. I, and perhaps Mr. Kay, expect to see a reply to the effect that the L.A. do cater for the "special" and "university" librarian, but the attempt of the Association has been only as the result of having "to do something" in the attempts to retain membership, and consequently fall short of the real need.

This is not a new question and if the L.A. and Aslib wish to do something then I suggest it's time some practical results were forthcoming.

I therefore sign myself a special librarian.

E. F. BROOME

Dorking, Surrey,
July 23rd.

SIR,—Mr. A. G. Kay's article on the above subject has been of particular interest to me, because of its relation to the substance of my own article which appeared in the "Times Review of Industry," April, 1952, page 17, "Works Libraries as an Aid to Production," and my correspondence following on Mr. K. J. Rider's article, "Library Service for Industry," THE ENGINEER, February 13, 1953. Although Mr. Kay makes a case for the difference between the public library and the special library, I, personally, feel that too little emphasis has been placed on the techniques of the special library work to justify the title "Qualifications for Special Library Work" and, whilst admiring and appreciating the literary ability of Mr. Kay, still think that his interesting article bears the stamp of the intelligence officer rather than that of the librarian.

I agree with him that the L.A. qualification, though a very valuable asset to the public librarian, is not a necessary one, though a useful one, to the special librarian in its present form, in particular to the industrial librarian. I wonder, too, if Mr. Kay is aware that almost all the activities he lays down for the intelligence officer on page 132 are carried out by many industrial librarians in the Sheffield district. The suggestion made by Mr. Kay that the special librarian need not be trained in a public library will be endorsed by many of the industrial librarians and in order to encourage the establishment of libraries in industry it has long been necessary to fill a long felt want by giving management the "know how." An attempt to fill this want is made in my "The Industrial Library," now with Butterworths Scientific Publications, which takes the reader through the whole processes from the establishment to the management of the industrial library.

I give my thanks to Mr. Kay for stimulating the interest in the work of the special librarians and for pointing out the important differences between the work of the public librarian and the special librarian.

HAROLD K. STYRING, A.I.L.

Sheffield,
July 23rd.

Explosion Characteristics of a Lubricating Oil Mist

By J. H. BURGOYNE,* D. M. NEWITT* and A. THOMAS*

Crankcase explosions are thought to be most commonly due to the ignition by an overheated part of a mist formed through contact of lubricating oil with the overheated area. It has been found that a typical oil mist formed in this way has a lower limit of inflammability of about 0·049 oz/cu. ft (or g/litre) of air, and becomes completely non-inflammable in air containing 28·3 per cent by volume of carbon dioxide. Its maximum burning velocity of 0·044 g/sq. cm sec at normal temperatures is attained with a mixture somewhat richer than stoichiometric; and at 100 deg. Cent. the burning velocity of a given mixture is increased by some 30 per cent. These explosion properties are such as would be expected if the oil existed in the vapour state instead of as a mist. Moreover, such variations of droplet size as are possible by ordinary changes in the conditions of formation of the mist seem to have no appreciable effect on the properties. Wider changes must, of necessity, have some effect, however, and this point is being further studied.

CRANKCASE explosions occur very rarely having regard to the number of engines, large and small, in daily use. A few times in a year, however, such an incident occurs with results that are usually not serious, but are occasionally disastrous. Thus a marine crankcase explosion in 1947 led to the loss of twenty-eight lives, and it was this disaster that brought the authors to undertake for the British Shipbuilding Research Association a comprehensive experimental investigation into such occurrences.

The available evidence suggests that in crankcase explosions the explosive medium is formed from lubricating oil and air. The general temperature in the crankcase is not high enough to give rise to any appreciable pressure of lubricating oil vapour, but a suspension of droplets may form either by mechanical dispersion of the oil or by its volatilisation in contact with a hot engine part followed by condensation as a mist. The volatility of the lubricant may, of course, be increased by fuel oil dilution, but so far there has been no indication that this is an essential feature of crankcase explosions, which have indeed occurred in steam engines.

Mechanically dispersed oil spray is present in a crankcase during normal running. Some condensed mist may also be expected for the reason that the lubricated parts tend to be at temperatures above the average in the crankcase. These normal temperature differences are not, however, sufficient to give rise to rapid mist formation and the ordinary breathing of the crankcase may well maintain the mist concentration at a sufficiently low level to be safe.

On the other hand, in the event of serious overheating of a lubricated part, condensed mist formation is accelerated and will proceed rapidly so long as overheating of the part and the supply of oil to it continue. Condensed mist is often referred to by engineers as "smoke," and is a recognised sign of overheating. Its formation may be accompanied by some decomposition of the oil to form gases and vapours that are also inflammable. At the same time the overheated part constitutes a potential source of ignition and the essential elements for an explosion are present.

It is thought that the majority of crankcase explosions originate in this way and for this reason the investigation was at first concerned with the behaviour of condensed oil mist rather than that of the coarser mechanical spray. However, the spray, although probably less easily ignited than the mist, is capable of taking part in an explosion, and since it forms the major combustible constituent of the crankcase in normal operation, its properties, too, require examination. Such an examination has been undertaken with results that will be published later.

The ability of the condensed mist to ignite and to continue to react explosively is a function of the oil-air ratio and of the droplet size. Below a certain concentration of oil in air the suspension cannot propagate flame, and it is clearly important to determine this concentration and to ascertain whether it changes with the limited variation in droplet size that is found in suspensions formed by condensation. These points are examined in the first part of the experimental work now to be described.

In the event of excessive mist formation in a crankcase, a practical step to avert explosion is the injection of inert gas. In this connection some knowledge is required of the minimum amount of inert gas needed for complete immunity; and in the second part of the experimental work relevant measurements with carbon dioxide are described. From the results estimates can be made of the requisite amounts for safety of other gases such as nitrogen, steam or an exhaust gas of stated composition.

With the knowledge thus obtained, certain steps can be taken to avert explosion. Thus, by the use of some form of automatic smoke detector† immediate warning can be given of the generation of a dangerously high concentration of mist. By ventilation or the injection of inert gas the mist concentration can then be kept outside the explosive range until the cause of the mist formation has been found and dealt with.

One must envisage the possibility, however, that such steps may be impracticable and an explosion may therefore occur. In such circumstances damage to the crankcase may be prevented by the method of explosion relief, whereby the explosion pressure is released by means of suitable valves and thus maintained at a level which the crankcase can withstand. A basic requirement for calculations leading to the design of explosion relief valves is a knowledge of the burning velocity (or fundamental flame speed) characteristics of the explosive medium. In the third part of the experimental work this information is derived. In a further investigation for the British Shipbuilding Research Association large-

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† A common form of automatic smoke detector that might find use in crankcases is that in which the smoke interrupts a beam of light falling on a photoelectric cell. Consequent electrical changes in the circuit of the cell are caused to actuate an alarm mechanism.

scale experiments have been undertaken to elucidate the principles of the design of explosion relief valves.

Experimental

Material.—Throughout the experimental work the oil used was Shell lubricating oil, Talpa 30. In a straight distillation this came over in the range 153 deg. Cent. (first drop) to 398 deg. Cent.

(1) Determination of the Lower Limit of Inflammability

(*a*) *Apparatus and Method.*—A diagram of the apparatus for the generation of the condensed mist and for the study of explosive concentrations is shown in Fig. 1. The principle of generation is that the oil is

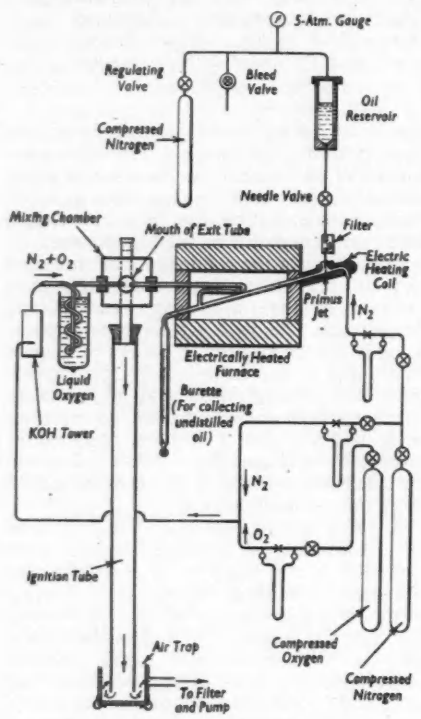


Fig. 1—Mist generator and ignition tube

evaporated at high temperature in a stream of nitrogen which then impinges on a stream of cooled oxygen-enriched air : a suspension of oil droplets is thereupon formed by condensation. The ratio of oxygen to nitrogen in the supporting medium is adjusted, through the relative flow rates, to be as in air.

The oil contained in a brass reservoir of some 500ml. capacity, was expelled by nitrogen pressure via a filter through a primus jet into the sloping "Pyrex" evaporator tube through which nitrogen flowed at a measured rate. In the furnace the oil was volatilised almost completely (at 430 deg. to 440 deg. Cent.) and in the mixing chamber the nitrogen-oil stream met the stream of enriched air, which had been cooled by passage through a copper spiral immersed in liquid oxygen. The distance between the jets through which the two streams issued into the mixing chamber was adjustable. The suspension formed was led off through a tube in the side of the chamber to the combustion apparatus.

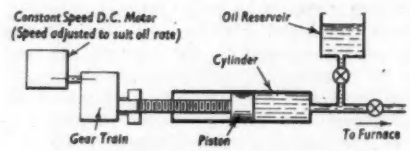
For the purpose of studying inflammable concentrations, the mist was passed down a vertical 2½in diameter glass tube of length about 5ft. That issuing from the lower end was extracted to waste through an oil filter. Back currents of air up the tube, which disturb conditions near the lower end, were avoided by fitting a brass cup around the bottom of the tube as shown.

To test a given mixture for inflammability, the cup was removed from the bottom of the tube and a ¾in high spirit-lamp flame applied. If the mixture ignited and flame propagated right to the top of the tube, the mixture was adjudged inflammable, but otherwise not. By varying the nitrogen pressure in the oil reservoir, the proportion of oil in the suspension was adjusted until it was the minimum for complete flame propagation. Before further altering the settings of flow rates the mixture actually reaching the bottom of the tube was sampled for size analysis and a measurement made of oil concentration.

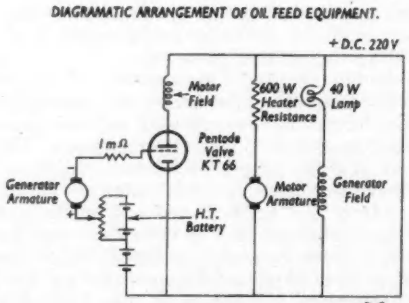
To sample for size, a glass cover slip carefully washed with solvents and polished with powdered magnesium oxide was momentarily held in the mist stream. The cover-slip was immediately mounted, in an inverted position, on a slide and examined by means of a projection microscope. Estimation of the drop size distribution was effected by comparison with the image of a graticule, incorporated in the eye-piece of the microscope, and superimposed on the image of the sample. The method of counting and deriving the size distribution has been described by Fairs (*Chem. & Ind. Vol.* 62 (1943), page 374).

Concentration analysis was effected by withdrawing a measured volume of the mist through a weighed filter which retained the oil drops. The weight of the oil was, of course, equal to the increase in weight of the filter. The filter consisted of a 1in diameter glass tube, packed with a 1in deep bed of stillite (slag wool) between supporting copper gauzes. The air was sucked out by a special aspirator which automatically withdrew a certain volume. The mist for concentration analysis was withdrawn isokinetically and the concentration was corrected to give the stationary concentration in the main stream of mist.

It should be noted that the method of limit measurement described will only give a valid result if the rate of the linear flow of the suspension is somewhat less than the limit flame-speed. The flow-rate actually



DIAGRAMATIC ARRANGEMENT OF OIL FEED EQUIPMENT.



MOTOR CONTROL CIRCUIT.

Fig. 2—Oil feed system

employed was 2–3cm per second and the tube was swept out for three minutes before a test, increasing to ten minutes when approaching limit concentrations.

(*b*) *Results.*—Preliminary experiments indicated that the oil arriving in suspension at the bottom of the ignition tube did not differ perceptibly from that entering the evaporator. In other words, no evidence was found of chemical decomposition of the oil in the evaporator or of separation of the constituent fractions.

Lower-limit determinations were therefore made using different jet-separation distances in the mixing chamber, whereby it was hoped that the drop size of the mist would be varied. In Table I are given drop-size analyses of samples taken with the different jet settings, together with corresponding limit-concentration measurements as observed and as corrected for differential settling of the drops of different size. Comparison of the corrected limits indicates that over the drop-size range considered, variation in size has no significant effect upon the lower limit, the mean value of which is 49·3mg per litre or 0·049oz per cubic foot. At this concentration the optical density of the mist is quite high. Efforts to define an upper limit of inflammability were not successful but it was found that flames could be propagated through mists of exceedingly high density.

(2) Determination of the Effect of Carbon Dioxide on the Range of Inflammability

(*a*) *Apparatus and Method.*—The apparatus was similar in principle to that previously described, but improved forms of oil feed,

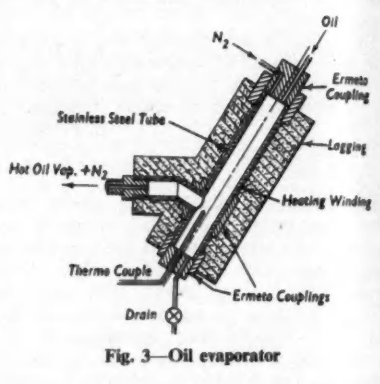


Fig. 3—Oil evaporator

evaporator and mixing chamber were employed.

The improved arrangements for feeding the oil to the evaporator are shown in Fig. 2. A velodyne motor-generator, having a constant but controllable speed, operated a piston through a gear train and screw thread, and displaced oil from a brass cylinder. The time of complete discharge was from five to eight hours. The cylinder could be refilled from an oil reservoir by reversing the motion of the piston.

The control circuit for the motor generator is also shown in Fig. 2. The generator produced a d.c. voltage, the negative side of which was applied to the grid of the valve. An increase in the speed of the motor caused the grid to become more negative, and the speed was balanced about a certain value. The actual speed was controlled by adjusting the bias voltage taken from the H.T. battery.

The oil cylinder was linked by polyvinyl chloride tubing (to avoid transmitting vibration) to the evaporator shown in Fig. 3. This was constructed of stainless steel, wound with nichrome heating wire and lagged with slag wool. The temperature was read by means of a thermo-couple placed at the "T" junction.

The brass mixing chamber is shown in Fig. 4. It was designed to minimise heat transfer between the cold and hot streams prior to mixing and to allow easy and accurate adjustment of the distance between the jets. The jets themselves were of thin-walled steel, mounted in "Tufnol" holders, of which the hot one was rigidly held in the body of the chamber. The cold holder could

be moved towards or away from the other by rotating the knurled nut.

For the purpose of the experiments with added carbon dioxide the mist was passed to the ignition tube as already described (see Fig. 1), but there was an additional connection to the top of the tube through which a controlled and metered flow of carbon dioxide was mixed with the mist on entry.

(*b*) *Results.* Preliminary tests with the new mist generating equipment indicated that under the conditions to be adopted there was no appreciable decomposition of the oil due

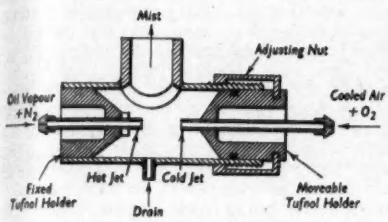


Fig. 4—Brass mixing chamber

to heating in the evaporator. The ratio of oxygen to nitrogen in the product entering the ignition tube was also checked and found to be as in air within the limit of error of the analysis.

Determinations of the lower limit of inflammability were made in the manner already described, but with increasing proportions of carbon dioxide present. Finally the proportion of carbon dioxide was increased just until no concentration of mist could be inflamed. This came about when the percentage by volume of carbon dioxide in the mixture : air+carbon dioxide was 28·3. At 28·0 per cent of carbon dioxide the mist was inflammable over a narrow range of concentration.

(3) Determination of Burning Velocity

(*a*) *Apparatus and Method.*—In these experiments the oil mist was generated by the improved method described in the preceding section and fed to a burner, where the burning velocity was measured by the Bunsen cone method.

The mist was led directly from the mixing chamber into the lower end of a brass burner tube, 1m in length and completely water-jacketed except for the lower 10-20cm. The exit temperature of the water (at the top of the tube) was measured by a mercury thermometer. The top face of the water jacket was machined flush with the end of the burner tube and the whole set up accurately vertical. The mist flowing up the burner tube burned with a steady flame at the outlet. The burner was contained in an enclosure and the products of combustion withdrawn by fan to the outdoor atmosphere.

A considerable amount of work was done on different methods of recording the flame cone photographically. After experimenting with direct, shadow, and schlieren methods it was decided to photograph the flame directly, using transverse illumination. The parts of the optical system, together with the burner tube, were clamped rigidly to a single duralumin girder, mounted on a suitable framework. The source of illumination was a high-pressure mercury arc lamp, and the flame, illuminated from the side, was photographed against a dark background. The camera was of full-plate size having a roller blind shutter. In general an f/4 lens was employed and the exposure was 1/75 sec., using H.P.3 plates.

A typical flame photograph is shown in Fig. 5. On this, two cones are clearly visible, the inner one consisting of the illuminated oil mist and the outer one being enclosed by the luminous combustion zone. Between these cones the oil is evidently in the vapour state and in process of mixing with the air and of preparation for the onset of flame.

Various methods have been proposed for the calculation of burning velocities from flame cone photographs. In the present

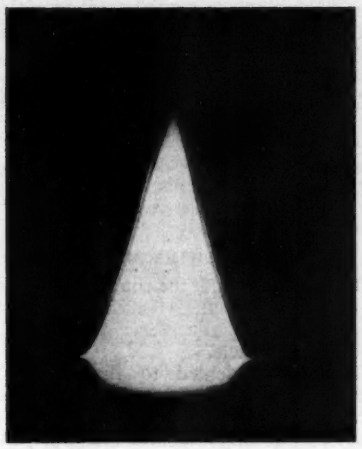


Fig. 5—Typical flame photograph showing two cones

instance it was decided simply to calculate the average burning velocity over the whole flame front by means of the relationship

$$\text{Burning velocity} = \frac{\text{rate of flow of mixture.}}{\text{area of flame front}}$$

The rate of flow of the mixture was ascertainable directly from the known rate of supply of air and oil to the burner. The area of the luminous flame front was, of course, that of the inside of the luminous cone as seen in Fig. 5. It was found, however, that this cone was less well defined than the mist cone, and somewhat distorted at the base. The burning velocity is defined and used in calculation, as being the velocity of propagation of the flame front relative to the unburned gas. A flame has thickness as well as area, and since lateral expansion of gases can occur within the flame thickness, the nearer to the unburned gas that the flame shape is measured the more valid will be the use of burning velocity estimated from that shape in subsequent calculations. It was therefore decided to take the area of the mist cone as the area of the flame front. Comparative measurements in a particular experiment showed that the area of the mist cone was about 2 per cent less than that of the luminous cone, from which it follows that the burning velocity measured from the mist cone is 2 per cent greater. From a practical standpoint it is more satisfactory to use the method giving the larger value of the burning velocity.

The area of the mist cone was estimated from the photographic plate by measurement with a travelling microscope. The diameter of the cone was measured at various heights from the base and thus the surface areas of the frustra between adjacent levels of measurement could be calculated. By summation, after taking account of the magnification in the photographic system, the total surface area of the mist cone was obtained.

In order to avoid confusion regarding the volume of the oil constituent of the burning mixture, the rate of flow of the mixture was expressed in gravimetric units. Hence, the burning velocity was calculated in the units: gram mixture/(sq cm flame-front) (sec).

Corresponding to each flame photograph, measurements were made of the concentration of oil in the suspension and also of the drop-size distribution. For the purpose of the former the flame was extinguished and the mist issuing from the end of the burner tube was sucked through a weighed slag-wool filter. The total flow of suspension was sucked through the filter for a certain time and the increase in weight noted. The air-flow rate being known, the concentration of oil could be calculated. To obtain a rough particle-size distribution, a clean slide was held across the end of the burner-tube outlet and the deposit analysed microscopically.

Since the mist velocity up through the burner tube was very much greater than the gravitational velocity of the largest particles in the mist, sedimentation had very little effect on the stationary concentrations of different particle sizes in the emergent mist : correction of the concentration for size distribution was thus unnecessary.

(*b*) *Results.*—In the main series of experiments, conditions of the formation of the mist and the burner temperature (20·9 deg. to 23·0 deg. Cent.) were kept constant as nearly as possible ; but the oil-air ratio was set at various values and the corresponding flames were photographed. In each case the oil concentration at the port was measured, and in Fig. 6 the observed relationship between burning velocity and oil concentration is shown graphically. Size analysis showed that few, if any, droplets above twenty microns were present and that the weight distribution mode was about twelve microns.

The stoichiometric mixtures of long-chain paraffin hydro-carbons with air contain about 6·3 per cent (by weight) of hydrocarbon, and it will be seen that the maximum burning velocity of about 0·044g/(sq cm

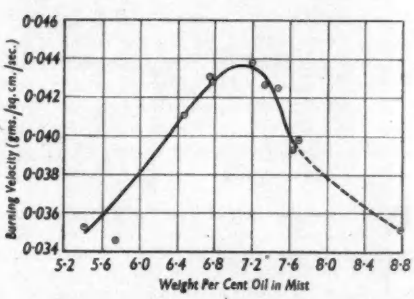


Fig. 6—Burning velocity curves for Shell " Talpa 30 " oil mist

sec) was observed at a somewhat higher oil concentration (about 7·2 per cent, by weight).

In two experiments the temperature of the burner was raised to about 100 deg. Cent. by passing steam through the jacket. Under these conditions, the measured burning velocities were : for 5·40 per cent concentration, 0·050g/(sq cm sec) (compared with 0·035 at about 22 deg. Cent.), and for 6·50 per cent concentration, 0·054g/(sq cm sec) (compared with 0·042 at about 22 deg. Cent.).

In other experiments, the conditions of formation of drops were varied so as to increase the average drop size. This was done either by increasing the temperature of the " cold " gas stream or by increasing the distance between the jets in the mixing chamber. The burning velocities measured under these conditions did not differ appreciably from those measured under normal conditions using the same oil concentrations. From this it may be concluded that the burning velocity is not very sensitive to droplet

size in the range of sizes found in condensed mists.

Conclusions

Oil mists formed by rapid condensation of the vapour have been found to have drop sizes chiefly below 20 microns, the greater part of the oil being present in the suspension as drops of about 10 microns. Such variations of size as have been achieved with this method of generation have had little effect either on the lower limit of inflammability of the mist or on its burning velocity at a particular oil concentration, although it is clear that a sufficient increase in drop size cannot fail to have effect. It may be tentatively concluded, however, that the size variations that may occur in practice in condensed mists have little significance in this respect.

The lower limit of inflammability of the condensed oil mist in air has been found to be about 0·049g/litre (or oz/cu ft), i.e. 3·9 per cent by weight. When the atmosphere consists of air containing not less than 28·3 per cent by volume of carbon dioxide, the mist is non-inflammable whatever the concentration of oil present. The maximum burning velocity of the mist at normal temperature occurs at an oil concentration of 7·2 per cent by weight and has the value 0·044g/(sq cm sec). At 100 deg. Cent. the burning velocity of a given mixture appears to be increased by some 30 per cent.

These properties are similar to those of the higher-paraffin hydro-carbon vapours burning in air and it seems unlikely that other paraffinic oils would give widely different results.

Table I.—*Effect of Jet Separation on Drop Size and Lower Limit*

Weight per cent on sample slide of drops between diameters (microns) :—	Jet separation (mm)		
	1	5	15
0·4— 0	0·0001	0·0003	0·00006
1·2— 0·4	0·11	0·125	0·04
2·4— 1·2	0·27	0·229	0·06
3·8— 2·4	3·98	0·648	0·72
5·4— 3·8	31·9	5·96	4·37
7·6— 5·4	41·5	20·10	20·3
10·8— 7·6	22·2	64·3	48·5
15·2—10·8	0	2·24	16·0
21·6—15·2	0	6·40	10·1
Lower limit of inflammability, mg/l*			
Observed	51·2	(*a*) 55·4 (*b*) 54·0†	(*a*) 56·0 (*b*) 55·8†
Corrected	48·6	(*a*) 50·1 (*b*) 48·8†	(*a*) 49·6 (*b*) 49·4†

* 1 mg/l = approx. 0·001 oz/c.ft.
† Duplicate determinations.

Acknowledgments

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3030 H.P. Electric Locomotives for South African Railways

Forty 3030 h.p. electric locomotives are being supplied by the North British Locomotive Company, Ltd., for the 3000V direct current sections of South African Railways. The locomotives are carried on two bogies, each with three driving axles and a leading pony axle. Provision is made for three motor combinations, each with a moderate range of field control, and for regenerative braking. The electrical equipment, as described here, is the responsibility of The General Electric Company, Ltd.

We illustrate herewith a 3030 h.p. electric locomotive, one of forty which are being supplied for service on the 3000V direct current sections of South African Railways. The main contractor for these locomotives is the North British Locomotive Company, Ltd., and the electrical equipment is being provided by The General Electric Company, Ltd.

It may be recalled that during the last twenty-five years the South African Railways have electrified large sections of their system at 3000V direct current and have now converted their Cape Western main line between Bellville, near Cape Town, and Touws River, a distance of about 149 miles. From Cape Town to Bellville on this route the existing 1500V direct current system is being changed over to 3000V ; beyond Bellville, the limit of the Cape Town suburban electrification, the work is entirely new, and was completed to Touws River on May 14th last.

Table I.—*Performance Requirements of 3000V D.C. Locomotives*

Type of train	Gradient	Max. speed required, m.p.h.
610-ton passenger ...	Level	56·5
	1 in 100 up...	38
	1 in 66 up	34
	1 in 50 up	31·5
	1 in 66 down	40 to 55
	1 in 50 down	30 to 45
900-ton goods	1 in 66 up	25·5 and 30
1070-ton goods	Level	35
	1 in 66 up	24·5
	1 in 66 down	25 to 40

All trains, both passenger and goods, running beyond Bellville are hauled by 3000V d.c electric locomotives, which are believed to be amongst the largest yet built for 3ft 6in gauge. The specified requirements covered both performance and train timings, the limiting factor as regards loading being the 20 miles of 1 in 66 gradient between Hex River and New Kleinstraat. On down gradients the speed had to be kept at the figures quoted in Table I by regenerative braking only. Furthermore, the locomotives had to be capable of starting a 1070-ton goods train on a 1 in 66 gradient or a 610-ton passenger train on a 1 in 50 gradient. The specified haulage requirements are given in Table I.

To meet these requirements a 3030 h.p. six-motor locomotive was provided, with three motor combinations and a moderate range of field control in each combination. Ultimately thirty of these locomotives will operate on the Cape Town-Touws River section and ten in Natal.

Mechanical Parts

The locomotive (Fig. 1) is carried on two bogies, each with three driving axles and a leading pony axle (Fig. 2). The draw gear is mounted directly on the bogie headstocks and the tractive effort is transmitted between the bogies by a link and pins with spherical bushes which allow freedom for transverse and vertical movement of one bogie relative to the other. The main frame of the locomotive is manufactured as three welded pieces, subsequently welded to each other to form a single unit with flat rubbing surfaces on the underside of the frame carried on spring-borne bearer pads on the bogies. On each bogie there are two main side bearers approximately opposite the pivot and two end bearers carrying slightly less weight at the inner and outer ends. The pivots carry neither weight nor tractive forces.

Transverse forces are transmitted from the pony truck to the bogie frame through rocker cams which provide a constant centring force. The bogie running is further stabilised by the friction at the bearers and by a spring interconnection of special design, which tends to keep the bogies moving in phase, but allows independent movement above a predetermined controlling force. The pony truck and leading driving axle are fully side and cross equalised, while the other two driving axles are side equalised only. The main dimensions of the locomotives are shown in Table II.

Table II.—*Main Dimensions of 3000V D.C. Locomotives*

Gauge	3ft 6in
Length over couplers	71ft 8in
Bogie wheel base...	22ft 5in
Total wheel base	60ft 4in
Wheel diameter (driving)	4ft 3in
Wheel diameter (pony)	2ft 6in
Total weight in working order	155 tons
Adhesive weight	129 tons
Tractive effort (at 25 per cent adhesion)...	72,000 lb
Continuous rating (full-field), T.E. at 28·5 m.p.h. ...	32,100 lb
Continuous rating (weak-field), T.E. at 37·6 m.p.h.	25,500 lb
One-hour rating (full-field), T.E. at 26·7 m.p.h. ...	41,700 lb
One-hour rating (weak-field), T.E. at 34·2 m.p.h....	33,600 lb

The locomotive body is symmetrically arranged with a driving cab at each end ; behind each cab is a machinery compartment, followed by a resistance compartment, and in the central portion of the locomotive there is an enclosed high-tension compartment (Fig. 3).

The driver's cab (Fig. 4) houses all the master

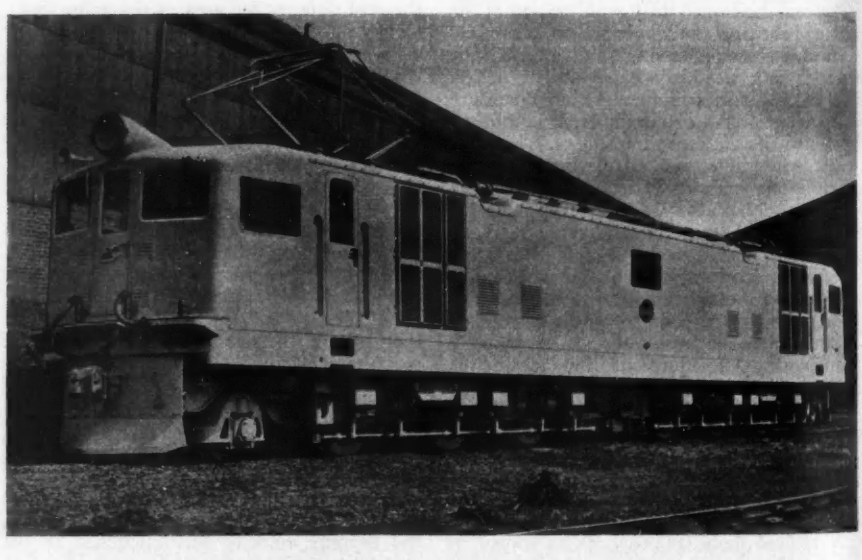


Fig. 1—South African Railways "4E" class 3030 h.p. 3000V direct current locomotive with six motor driven axles and two pony axles. Regenerative braking is provided

control equipment. A panel in front of the driver carries various meters and gauges, including a mileage counter, a regenerative mileage counter, and a speed recorder. On the right, at eye level, there is a speedometer. Behind the driver are the main control switch and circuit breakers for the lighting circuits. The battery is fitted in two cubicles on either side of the front doorway.

The machinery compartments contain the various auxiliary machines and much of the low-tension control equipment associated with them. The ventilation of the high-tension compartment is effected by diverting part of the cooling air from the ducts leading to the traction motors. All the cooling air for the locomotive is filtered.

Electrical Equipment

Power is collected from the overhead line by one of two pantographs ; all the circuits are fed through a main isolator interlocked with the h.t. chamber door and pantograph control. The locomotive performance requires three groupings of the six driving motors (series, series-parallel and parallel) both when motoring and regenerating. The motors are thus connected in series

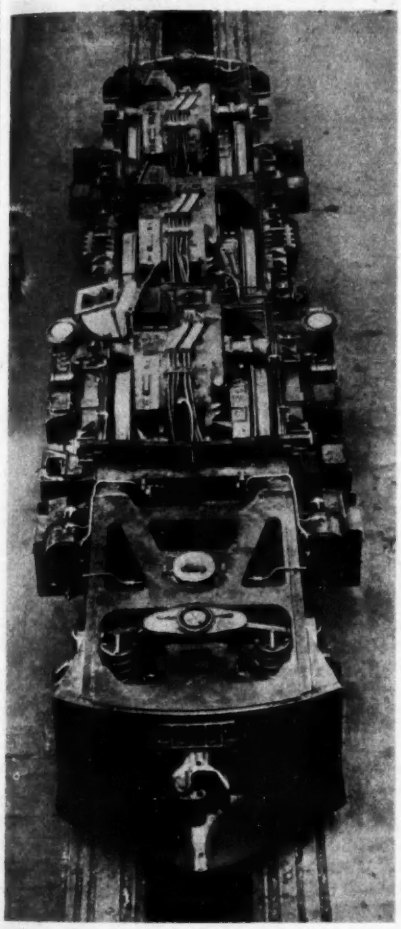


Fig. 2—Motor bogie and pony truck of 3030 h.p. electric locomotive. The bogie wheelbase is 22ft 5in

across the line as one group of six, two groups of three or three groups of two. Control is by means of electro-pneumatic contactors operated from the master controller (Fig. 5).

Changing from one combination of motors to another is by shunt transition which maintains a suitable drawbar pull during regrouping. In each combination four continuous running steps are provided by field excitation control. When regenerating, the motor fields are separately excited from a variable-voltage exciter and the inverse compound regenerative characteristic ensures stability. Lightning protection is given by means of a double spark gap and a surge absorber, both mounted on the roof, and auxiliary spark gaps with blow outs in the power and auxiliary circuits. All the high-tension equipment is designed to withstand 10,500V a.c.

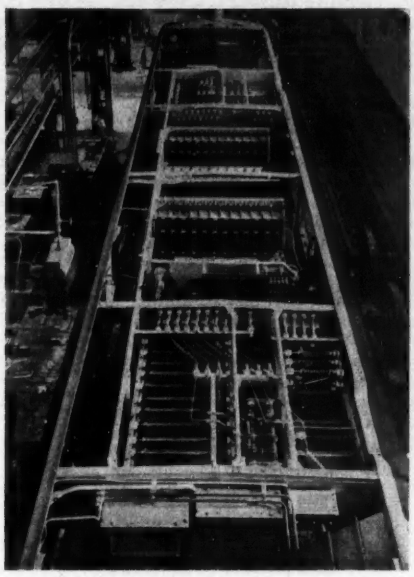


Fig. 3—High tension compartment and resistance compartments of 3030 h.p. locomotive

The power contactors are electro-pneumatically operated and the master controller handles only small currents at 112V for operating the valves. A comprehensive system of interlocks ensures correct sequence in all circuit changes and affords full protection in the event of failure of any component. The master controller has three handles. The first selects forward or reverse running as well as the various motor combinations ; the second controls the cutting out of starting resistance during motoring and regenerative braking, the final notches of this handle operating field weakening contactors in any motoring combination. Field weakening is not available when the motors are regenerating. The third handle sets up the regenerative connections and controls the exciter voltage. As the locomotives always have a crew of two, no " dead man's " device is provided.

Should over-current or over-voltage relays operate, starting resistance sections are at once connected in the circuit, followed by further sections, and finally by the opening of the line switches. If a motor fails, the three motors on either bogie may be isolated and the locomotive safely operated with a limited performance. All the locomotives are provided with control train lines and couplers to permit multiple-unit operation so that more than one locomotive can be driven from one cab.

To meet the requirements of the railway system the high-tension side is earthed, but the low-tension circuits are not earthed, because there may be a very high resistance to earth if sand or dirt is blown on to the track. Furthermore, there is always the equivalent of an earthed barrier between low and high-tension circuits when associated with one piece of apparatus.

The pantograph is of light-weight, heavy-duty construction, the pans being arranged to neutralise the drag action caused by friction.

The main 3000V, 300A contactors are electro-pneumatically operated and are tested with currents exceeding 8000A and voltages up to 4000V. A small 3000V clapper type solenoid-operated auxiliary contactor is built on similar lines. For the main change-over cam groups use is made of an insulated bar construction carrying the fixed and moving contacts ; a centre shaft carries the cams of synthetic-resin-bonded fabric to operate the contacts, which are spring closed and cam opened.

The master controller (Fig. 5) also employs eam operation, with silver butt contacts. There are three drums on the same centre : the top being the reverse and combination drum, the middle the regenerative, and the bottom the main resistance and weak field drum.

The motor resistances are of special corrosion-resisting cast iron, and the grids are carried on " Micanite " insulated bars. On each bar a take-up spring is provided to counteract slack, which would otherwise cause burning of the contact surfaces. Field weakening and regenerative stabilising resistances are of the strip type.

Each axle-hung traction motor is a four-pole, series-wound, force-ventilated machine, weighing 5¼ tons, with gears and gearcase. Motor ratings at 1450V in accordance with B.S. No. 173/1941 are : continuous rating, full field, 232A, 420 h.p., 672 r.p.m.; continuous rating, weak field, 242A, 440 h.p., 888 r.p.m.; one-hour rating, full field, 282A, 505 h.p., 630 r.p.m.; one-hour rating, weak field, 290A, 525 h.p., 807 r.p.m.

Each motor is suspended from the bogie transom by a nose cast on the frame and resting in a cradle carried on rubber pads. Manganese steel wearing surfaces are provided on the nose and cradle. The lateral forces imposed on the track are considerably reduced by allowing the motor a limited amount of transverse movement relative to the axle, under the control of rubber springs between the motor and the bogie frame. The suspension bearings are clamped in position by a single cast steel axle cap located by large spigots and secured by bolts. Lubrication of the suspension bearings is effected by oil siphoned through wool packing from a large reservoir in the axle cap.

The armature is carried in grease-lubricated roller bearings and can be removed from the motor frame without opening up the bearing assemblies, so that there is no risk of dirt entering the housings during this operation. Hard mica wraps moulded on the coils insulate the slot portion of the armature windings. The whole is consolidated, while hot, all interstices being filled with insulating cement. Because of armature failures in the past, caused by the melting of

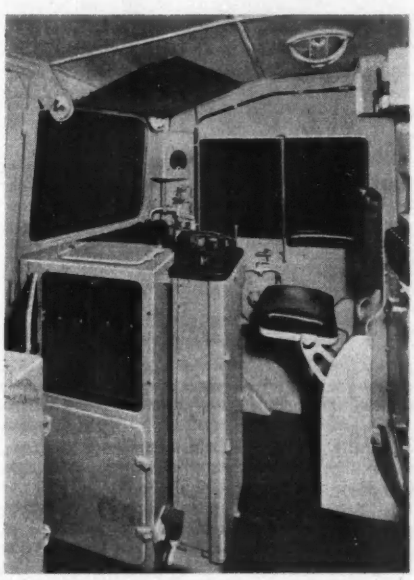


Fig. 4—Driving cab of 3030 h.p. electric locomotive. The master controller is on the left of the driver's seat and there is a battery compartment on each side of the front door

solder in the commutator joints, solder is used which does not become plastic until a temperature of 236 deg. Cent. is reached. The field coils are formed of copper strip with inter-turn insulation of treated asbestos : the main insulation is cambric-backed mica with an outer taping of asbestos. The final polymerisation of the impregnated synthetic resin varnish gives good mechanical strength, insulation, and heat dissipation properties.

Studs of fatigue-resistant alloy steel with non-magnetic bushes fix the interpoles to the motor frame. This construction, coupled with careful grading of the interpole gap, ensures proper interpole strength and greatly assists commutation.

The motors drive the axles through single spur reduction gearing manufactured by Alfred Wiseman, Ltd. The resilient gear wheels comprise a carbon chrome toothed rim mounted on a cast steel hub, the drive being transmitted from rim to hub through " Silentbloc " rubber units.

Good resilience is obtained by using two "Silentblocs" in series, one mounted in the rim, the other in the hub, with a steel pin forming the connecting link.

Each locomotive is provided with a 43kW motor exciter set which energises the motor fields when regenerative braking is used, and a 22kW motor generator for supplying the l.t. power and lighting circuits. In each set there is a blower, which supplies the cooling air for three of the traction motors. Both motor and generator armatures are mounted on a common shaft with the field system housed in a single fabricated frame ; the driving motors are two-pole machines

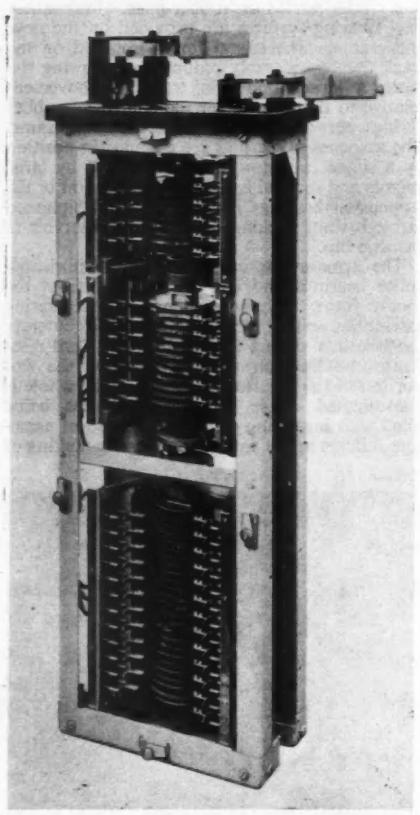


Fig. 5—Master controller with three drums on the same centres ; top, reverse and combination ; middle, regenerative ; bottom, main resistance and weak field

operating from the 3000V supply. The exciter and l.t. generator are four-pole machines. The equaliser connections of the exciter form part of the commutator assembly and are entirely separate from the main winding.

On the 22kW set the blower takes sufficient load to permit the use of a series-wound driving motor, but for the 43kW set an additional field is provided on the motor to limit the speed range between maximum and no load on the generator. Both the exciter set and the l.t. motor generator are force ventilated.

The driving motors of the exciter and l.t. generator are protected by a circuit breaker which can also be set and tripped by hand and serves as a means of starting and stopping the machines. Current from the l.t. generator is used for battery charging, for the fields of the exciter set, and for the two exhauster motors, compressor motor, lighting, control circuits and heaters. All these machines have automatic starting equipment to limit the starting current peak. All the lighting and control circuits are protected by circuit breakers, no fuses being used. The battery floats across the l.t. generator and supplies the lighting and control circuits if the l.t. generator is not running. In an emergency it can be used to run the exhausters for a limited period.

Brake Equipment

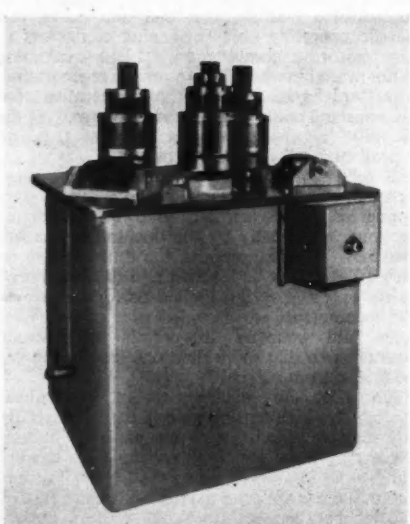
The Westinghouse brake equipment provides straight air brakes on the locomotive and means for operating vacuum brakes on the train. Regenerative braking is interconnected with the mechanical brakes so that, in the event of failure during regeneration, the vacuum brakes are automatically applied. The compressor is automatically controlled and supplies air via the main reservoir for the locomotive brakes, sanding, horn, control and pantograph equipment. Two vacuum exhausters operate the train brakes. The Westinghouse exhausters are driven by 110V series motors, the armature being mounted on an extension of the exhauster crankshaft, while the motor frame is spigoted to the crankcase. The brake rigging is fully compensated with brake blocks on each side of the twelve driving wheels, each bogie having two brake-operating cylinders. An automatic slack adjuster allows for wear of brake blocks and tyres.

Air sanding is operated by electro-pneumatic valves controlled by the driver. Each bogie has eight sanding boxes, so that, for either direction of travel of the locomotive, eight wheels are directly sanded.

Ring Rolling Machine

The illustration shows a ring rolling machine which is being manufactured by P. and L. Miller, Ltd., Heneage Street, London, E.1. The machine is capable of internally rolling mild steel angle up to 2½in by 2½in by ⅜in (3in by 3in by ⅜in with external rolling), or equivalent sections of maximum modulus 0·9. The minimum inside diameter to which the machine will roll is 10in.

The twin main rollers are contained in a steel housing, which is actuated sideways within the frame by means of a pair of coupled left and right-handed tensioning screws, operated by a hand wheel. The centre pressure roller shaft is contained in a steel casting which is hinged within the main frame. This allows adjustment of the roller. The two guide rollers are independently adjustable, both radially and



Ring rolling machine for up to 3in by 3in by ⅜in mild steel angle, minimum rolled diameter 10in

axially, to suit varying diameters. The twin main rollers and pressure rollers are equipped with threaded sleeves and are adjustable to accommodate all standard sections. Rollers to suit tubes can also be supplied. All three rollers can be driven or allowed to run free by operating a lever on the side of the machine.

The roll shafts are carried in needle type bearings. All other bearings are of self-lubricating bronze.

The drive is from the motor pinion through a fabric intermediate gear to a worm and worm wheel reduction gear. From the worm wheel shaft a train of spur gears transmits the drive to all three roll shafts.

The frame of the machine is fabricated and has been designed for strength and accessibility. Sheet metal covers completely shroud the mechanism but can readily be removed for servicing. A smaller version is also manufactured, which is suitable for up to 1½in by 1½in by ¼in mild steel angle, or equivalent sections.

Geared Motor Units

An addition to the range of "Coventry" geared motors has recently been made by The Coventry Gear Company, of Foleshill, Coventry, a member of the David Brown Group. The new unit, known as the "1⅝" model, is manufactured in either double or triple reduction form.

"Coventry" motors of the protected and totally enclosed type, with a fully loaded speed of approximately 1425 r.p.m., are normally fitted but other makes of motor can be fitted if required. A choice of seventeen output speeds, ranging from 25 to 345 r.p.m., is available, with an equivalent variation of input powers from 0·16 h.p. to 0·75 h.p.

The motors can be mounted in any of six operating positions. Lubrication, oil level

Geared motor unit, showing compact design ; speed range 25 to 345 r.p.m. Vertical mounting may be specified

inspection, draining and refilling can be carried out without difficulty in any of these positions.

The total height of the units is very little greater than that of the motors alone, which renders them particularly suitable for installation in confined spaces.

The gear units are also available without motors. In such cases the motor adaptors are replaced by modified covers and the input and output shafts are coaxial.

The gears are precision cut, the first reduction gears being of the single helical type, while second and third reductions are spur gears.

The case is a one-piece iron casting and incorporates a combined filling and ventilation plug, drain plug and oil level indicator.

The gears are splash-lubricated and the internal arrangement ensures an adequate flow of oil to each bearing. When vertical mounting of the unit is specified a screw pump is incorporated to provide a positive oil feed to the top bearing and gears.

Volumetric Glassware—The sixth booklet in the National Physical Laboratory series "Notes on Applied Science," has been published. It contains complete basic scientific information on the design and accuracy of volumetric glassware. The British volumetric glassware industry has grown up wtih scientific principles as the foundation of its success and the N.P.L. has always been connected with its development. The original British Standards for the industry were worked out with the N.P.L. and they have been revised and added to since the war in co-operation with manufacturers and users. "Notes on Applied Science No. 6" describes the scientific requirements on which standards for volumetric glassware must be based and sets out the main features of standardisation. The special features of particular instruments are also dealt with. For vessels intended to deliver a specified volume, examples showing the need for close control of the conditions of delivery are given. The booklet includes sections on the basis of graduation, the construction and verification of apparatus and the dependence of volume delivered on delivery procedure. "Notes on Applied Science No. 6, 'Volumetric Glassware : Scientific Aspects of Design and Accuracy,'" is published for the D.S.I.R. by H.M. Stationery Office, price 1s. 6d. (40 cents U.S.A.), by post 1s. 7½d.

The Technical Interpreter

(Contributed)

The technical interpreter, discussed in this article, has the function, in industry, of communicating technical facts and conclusions to all interested readers. The discussion specifically excludes the technical journalist. The qualities of a good interpreter are discussed and it is pointed out that the interpreter is often inefficiently employed in duplicating the technician's work. It concludes that industry should accept responsibility for applying proper guidance at the right stage.

THE importance, in industrial affairs, of conveying technical information correctly and clearly is being increasingly appreciated. It is realised that the vehicle for conveying ideas or instructions must neither creak nor break down, nor wander off on journeys of its own accord ; that the language and its arrangement must transmit precisely the facts with precisely the emphasis intended, in the way that will be understood with least effort and time by the reader addressed.

To the technical journalist—with whom this discussion is not concerned—those requirements form working principles applied in all responsible journals. In the comparatively private world of industrial reporting the problem is only beginning to be understood and a solution is only beginning to emerge. Whether that solution is wholly a satisfactory one is open to doubt.

The technical writer within industry operates in several ways, and under various titles, according to the nature and size of the organisation he serves. He may produce anything from a list of parts to a report of research ; he may be called technical writer, information officer, technical sales assistant, personal assistant to managing director, or he may be an anonymous member of the publicity department. But in one of his functions he has been aptly described as an interpreter, and it is thus that he makes his most important contribution to the free flowing of information.

His scope embraces information flowing from one technician to another, from technician to management, and sometimes from technician to the public. His work in this function is factual and, with rare exceptions, is not creative or provocative. Unlike the technical journalist, he is not expected as an interpreter to stimulate interest and keep an industry on its toes ; unlike the publicity writer, he is not required as an interpreter to persuade. His duty is to convey technical information in the form in which his several readers can use it : nothing more, but certainly nothing less.

A simple example will illustrate this function of the technical writer and lay a foundation for certain conclusions. It often happens that the pros and cons of a new device or project must be submitted by a managing director to the fellow-members of his board for decision as to whether or not money and plant shall be allocated to it. Now the board does not concern itself with calculations and blueprints. Taking for granted the competence of its staff, the board will want to relate their findings to its own background of knowledge on finance, political economy and the overall plan for the organisation. These subjects form the technical equipment of the board members : consequently the board is not—as staff members so often allege—a lay body, but a technical body and must be addressed in terms that take its own particular technical knowledge and experience into account.

Further, the board may query the success of the project under circumstances not catered for in the original scheme, but which some member now foresees ; or query the possibility of modifying the device for use in a different market in which someone else has influence. The managing director may have to combat the proposal to use an alternative, but unsuitable, raw material from another "interested quarter." He will have foreseen most of these questions and be armed with a private briefing from his departmental heads : research, production, purchasing, and so on. This second and longer document will also be factual, but the facts will be linked with arguments, supported by figures (not calculations) and possibly by graphs. This information must be precisely ordered for quick reference, it must be consistently accurate within the tolerance expected, and it must be perfectly clear as to where fact meets hypothesis.

Thus, between the departmental reports and the statement at the board meeting there are two stages of highly intelligent appraisal, sorting and arrangement of complex detail. But more is needed than straightforward selection and compression. There must be the process called interpretation : "putting it in the way they understand," and the investigator can seldom do this for himself ; he is too close to his own detail, and also his inclination is to speak to others, not in their language, but in the way he himself understands. Hence the employment, on many organisations, of a separate interpreter.

Now the value of such an interpreter can be very great ; but so can be his (or her) nuisance value. By intelligent selection he can save other people hours of unnecessary reading, but he can also cause days of delay by omitting a single factor because he has missed its significance. By changing the order of two phrases he can bring to light a hidden relationship between effect and cause, but he can also create a fictitious relationship if he pays more attention to literary pattern than to technical presentation.

Good interpretations can be produced by a non-technical writer, if he is equipped with unusual shrewdness and a deep understanding of his readers. He is handicapped, however, by his dependence upon what he is given and told—he can ask questions, but he can rarely himself check from first principles. Experience suggests that the interpreter having sound knowledge of his subject is, on the whole, better equipped to give an accurate interpretation quickly and without bothering other people. His besetting sin—at least, his temptation—is to impose upon the writing of others a technical viewpoint of his own ; although this may not affect the facts, it is likely to upset the balance of their presentation.

Technical writers on industrial staffs are themselves concerned about their qualifications, training and status. They are fully alive to the fact that for them no recognised examination qualifications exist, although many of them are science degree men, who, after a period in practice, have drifted by inclination or accident to the writing side. The "Presentation of Technical Information Discussion Group," whose honorary secretary is a full-time lecturer on the subject at University College, London, is doing useful work. The Group covers all forms of presentation—writing, speaking, display—with considerable emphasis on writing. Its meetings are lively and informative, with a refreshing absence of pedagogic bickering over grammar, and show much greater concern with quality of work than with recognition and status. The latter are not forgotten, however, and in particular it is realised that technical writers are neither easily found nor easily fitted into an industrial organisation.

One reason for the dearth of interpreters (to revert to a very descriptive term) is little realised. It is, simply, that very few science graduates want to give up science in order to make other people's reports coherent, or describe other people's work. They want, themselves, to be in the laboratory, or the works, or out on a contract ; and if they must make reports, they want to report their own investigations. So we come full circle, because the possession of a scientifically trained mind does not guarantee the ability to express thought plainly on paper. Technical people sometimes complain bitterly that their reports are mangled by "someone in the office who is blue-pencil happy." That is a very bad thing to happen—a real error—but it is often made possible because the technician will not treat his own writing sensibly. His technical terms can be checked easily enough, if necessary ; the obstacles to correct understanding are his weakness for omnibus words and telescopic sentences, sometimes his desire to be stylish rather than plain, and overall his lack of sympathy for his reader. Even to say—as he is mistakenly prone to—that he is a plain, blunt engineer, using language that other plain, blunt engineers will understand, is no answer : we all know that screws can be driven in with a hammer, but as engineers we just don't do it.

The technician who does not bother to use words helpfully and effectively is rather like the man who opens his front door with a bit of wire because he hasn't yet found out about keys. Both waste their own and other people's time ; both tend to be misunderstood. For the technician, we have to use—or rather misuse—the interpreter, in order to deduce what the original writing means before any attempt can be made to transmit it to other people. To the extent that the interpreter must do again the original writer's work, the interpreter is being employed inefficiently. For this reason it is suggested that the separate interpreter—technical writer, information officer or what you will—is not the wholly satisfactory solution to this problem of presenting technical information.

The wholly satisfactory solution is of two parts : (i) the plain, clear statement by the scientist or technician with something to say ; and (ii) the interpretation by an objective writer to suit different readers. The second part has emerged, as already described, but the first scarcely exists. In consequence much time is wasted in questioning, referring back and checking, and a good many risks of inaccuracy are run.

The answer rests with the training of scientists, engineers and the rest of the technical world. No doubt the colleges will pass the blame for slovenly expression back to the technical schools, the technical schools to the primaries, the primary schools to the parents. But industry cannot dodge its own responsibility. Industry to-day has a big responsibility, and a big opportunity, in the training of its own people. Industry founds and supports scholarships and chairs ; industry sends professors to colleges and lecturers to schools ; industry co-operates with education in providing teaching space and equip-

ment. All this for ensuring that future entrants to industry are well stocked with knowledge, but practically nothing to ensure that they know how to issue the stock.

Industry must help to decide where inarticulateness shall be tackled: in the training of the student, so freeing his mind for life; or by remedy after he has entered practice—a remedy applied in industry's time, and a remedy from which the sufferer himself rarely learns. The answer must surely be training applied at the earliest stage and certainly continued throughout college or technical school life. Time for deliberate, planned instruction must be found and, indeed, it lies to hand. Time at present wasted in writing and rewriting weekly essays; time used in correcting and re-correcting; time wasted in the examination room. But industry must acknowledge that plain writing is not a natural gift, but a technique to be learned, and as necessary to the scientist and engineer as an understanding of Boyle's law or Archimedes principle.

Fuel Research Report

In the report of the Fuel Research Board for 1953, with the report of the director of fuel research, which was published earlier this month, reference was made to the increased public attention to one of the effects of the inefficient use of fuel, namely, air pollution, emphasising how closely the Fuel Research organisation is linked to this aspect of fuel economy. It noted that the use in industry of Fuel Research Station smoke eliminator doors for hand-fired, natural-draught boilers is extending, which effects not only a decrease in atmospheric pollution, but also an increase in boiler efficiency and a saving of fuel approaching 1,000,000 tons per year.

Details were given of progress during the year in washing flue gases with ammonia to remove sulphur compounds and recover ammonium sulphate and sulphur. It was shown how basic investigations of the vapour pressures of the ammonia-water-sulphur-dioxide system had helped this work.

Improved equipment was also developed for recording the amount of smoke passing up domestic chimneys and a start was made on a more intensive investigation than hitherto on the factors effecting production of smoke from open fires. At the same time, work was restarted on the manufacture of coke that would be easier to burn than present-day gas coke, using typical gasworks equipment, but modified conditions of carbonisation. Cokes which burnt satisfactorily on an ordinary domestic grate had been produced in this way from a weakly caking Nottinghamshire coal.

There were about 1400 pollution measuring instruments in regular use throughout the country, which were providing a means of ascertaining how the pollution at ground level in certain districts varies with the amount of polluting substances emitted from given industrial installations, and with meteorological conditions.

Work was in progress on the utilisation of fine low-grade coal and coke. Observations had been made on the burning of such fuels in boiler furnaces of different kinds, that may enable a grate to be designed without the use of very small openings which tend to become choked with fine ash and fuel. On the gasification side attention was devoted mainly to the production of water-gas and producer gas from weakly caking coal using the fluidised solids technique. Originally, much of the fuel was lost as dust and although alterations to the pilot plant have now reduced this loss considerably, further reduction is necessary. A slagging cyclone generator had been used with some success to gasify crushed coal using a blast enriched with oxygen.

The report explained that when pyrites was roasted for the manufacture of sulphuric acid the residues of iron oxide are ordinarily mixed with iron ore, and smelted in blast-furnaces. It has now been found advantageous to use a burner at sulphuric acid works which requires finely divided pyrites and produces a residue unsuitable for smelting. Samples of these residues had been mixed with coking coal and carbonised in intermittent vertical chambers to see whether a coke with a high iron content could be produced that would still be strong enough for use in blast-furnaces. The results so far obtained, the report maintains, are distinctly promising.

With the increased use of pulverised coal in electricity generating stations a new type of deposit, bonded by calcium salts, which is now being investigated, may cause trouble when coals are burnt which have a high content of chlorine, in addition to the usual amounts of calcium and sulphur.

During the last few years local housing authorities have been advised to install, as the principal heating appliance in each house, domestic heating appliances that have passed a series of efficiency tests. The methods of testing and the standards required have been revised in the light of experience and as the result of special investigations at the Fuel Research Station. The new testing schedule came into operation on July 1, 1953. Considerable progress had been made in basic research on room heating efficiency. For these investigations the Calorimeter Building provided facilities that were unique.

Mechanical Engineering Research 1953

The report of the Mechanical Engineering Research Laboratory at East Kilbride was published last week, and items of research from the various divisions of the establishment are briefly noted below.

Much of the effort of the fluid mechanics division was concentrated on the design and development of equipment for the hydraulic machinery laboratory. Very steady and consistent dynamic measurements of pressure and direction of flow have been achieved using electrical pick-ups, sensitive to high frequencies, inserted directly in the volute of a centrifugal pump. Over a period of some weeks the pressure variation was less than $\pm 0{\cdot}1$ per cent and the yaw variation less than $\pm \frac{1}{4}$ deg.

To measure water flow rate in model tests to the desired accuracy of $\pm 0{\cdot}1$ per cent, liquid is diverted into a weighed tank. This has a capacity of 30 tons and is supported by a beam on two hydraulic load cells, in which oil pressure is measured remotely by a small automatic weighing unit.

A detailed study has been made of various forms of probe for investigating two and three-dimensional flow to develop a robust instrument for general laboratory use. Tests on a pitot tube at low speeds of water flow have shown that at Reynolds numbers between 180 and 500, based on instrument head diameter, it reads less than the true velocity head. At lower Reynolds numbers the instrument reads more than the true velocity head.

The design of high-speed journal bearings for use in gas turbines is one of the researches in division D of the establishment, which is responsible for lubrication and wear research and mechanical engineering aspects of corrosion.

As gas turbines operate at speeds above those at which ball and roller bearings can be expected to work reliably, the behaviour of journal bearings at high speeds is being investigated, and particular attention is being paid to the problems of loss of power through frictional drag. The behaviour of lubricating oils under operating conditions is an obvious factor in the problem and the flow of oil is being studied by using transparent bearings and making the flow visible under ultra-violet radiation by the addition of a fluorescent dye to the oil. Results so far obtained show that bearings which are short in relation to the diameter of the journal are most efficient for high-speed work.

The design of the oil passages by which lubricant reaches the unloaded part of the bearing is of great importance for satisfactory operation.

Fretting Corrosion.—In an investigation of fretting corrosion, a form of wear caused by continuous small relative movements between mating surfaces, it was found that the displacement/time characteristic of the movement greatly affects the amount of damage that occurs. For instance, an oscillating motion of square wave-form causes twice as much damage to steel specimen as a sinusoidal motion of similar amplitude.

As the severe pitting of steel surfaces is accompanied by the formation of ferric oxide particles, which are bad electrical conductors, it has been possible to study the progress of fretting by making contact-resistance measurements. These show, the report notes, that resistance rises from around zero to a few ohms almost immediately fretting starts and increases rapidly after several thousand oscillations have taken place.

The electron microscope reveals that the early stages of wear are mainly due to the ploughing action of minute surface protuberances. These are considerably harder than the rest of the surface and they may be due to intermetallic welds or to the hard carbon phase of the steel.

Long duration tests are now being carried out to test the efficiency of various surface treatments which may inhibit fretting corrosion. A multiple fretting machine of simple design is being used for this purpose.

In division E, which is concerned with mechanisms, engineering metrology and noise control, work has continued on compression fatigue of spherical surfaces and upon the relationship between the highest dimensional accuracy with the minimum frictional torque in the design and manufacture of small precision ball bearings. It has also developed an automatic gear tooth indexing machine. The report states that the slow and tedious procedure of measuring errors in the spacing of teeth in gears is normally carried out in a manually operated machine. To inspect a gear with 100 teeth in this way takes two operators four hours. An automatic indexing machine for gears up to 24in in diameter has now been developed which carries out the test in half an hour and requires only a few minutes of one operator's time for the initial setting.

An N.P.L. type of gear tester was converted to automatic operation, the various components being operated pneumatically in sequence controlled by a camshaft operating a number of air valves. Errors in tooth spacing detected by a miniature gauging head are recorded on a chart and the machine stops automatically when the test is completed.

One of the principal items in the work of the mechanics of formation and machine shaping of materials, division F, has been research into the mechanism of the extrusion process on the three main extrusion products which are rods, Hooker tubes and tubular containers. Both direct extrusion, where the metal flows in the same direction as the punch, and inverted extrusion, where the metal flows in the opposite direction, have been studied. In studying the flow of the material during extrusion, cylindrical specimens were split and a square grid was inscribed on one of the parted faces. The halves of the specimen were then joined and extruded. By using a number of such specimens, and removing them at various stages of extrusion, complete flow patterns were obtained.

The flow investigations have yielded information on two important factors of commercial extrusion. These are piping, the tendency of extruded rods to become hollow, and the formation of dead metal zones in die chambers.

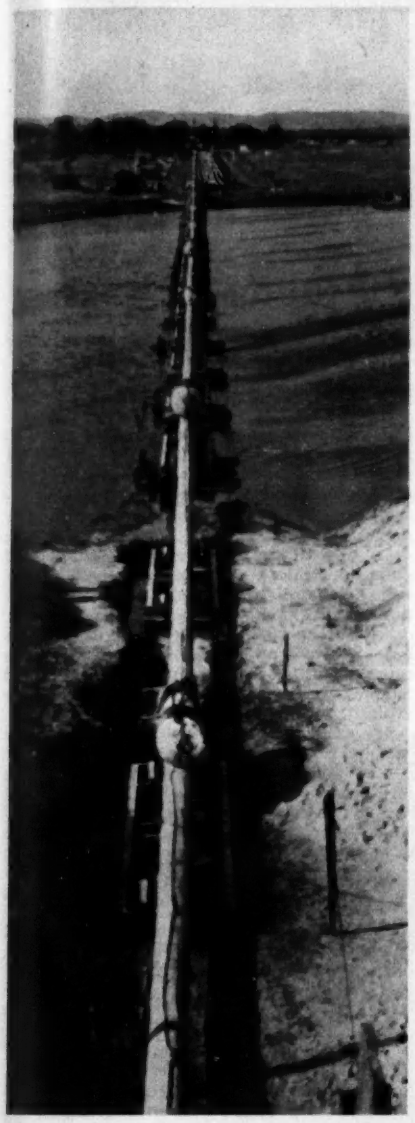
The report is published by H.M. Stationery Office, price by post 2s. 8d.

Diesel Engine Lubrication.—We have received from the Vacuum Oil Company, Ltd., a handbook entitled "Diesel Engine Lubrication," which is No. 9 in the Vacuum Technical Series. The fundamentals of diesel engine operation are reviewed followed by a discussion on the lubrication of the various parts of the engine. A section of the book is devoted to the various methods and systems of oil purification, including a note upon oil storage, while in the next chapter the storage and filtration of diesel engine fuel oil is considered. Diesel engine operating criteria is discussed next and this section of the book includes remarks upon piston and cylinder troubles, lubricating oil consumption, excessive wear on moving parts, oil pressure, dirty crankcases and cooling water systems. The selection of diesel engine lubricating oil forms the subject matter of the final section and contains general recommendations, together with particular references to cylinder and bearing lubricants.

Submarine Pipeline

To improve the commercial amenities of the Gold Coast a permanent submarine pipeline has been laid recently at Accra for the Socony Vacuum Oil Company (Gold Coast), Ltd. The pipeline, which replaces a temporary wartime "Pluto" installation, is 2½ miles long and enables tankers to anchor in Accra roads and discharge oil to the tank installations on shore. The line consists of 12in inside diameter heavy section pipe with bitumen and gunite coatings and equipped with cathodic protection.

Strings of pipe were assembled on shore by welding together individual 40ft lengths and a



Pipeline being towed out to sea. Rocking cradles and pontoons can be seen and, in the background, the pipe spread with several pipe strings ready to be launched

protective coating consisting of two spiral wraps of glass fibre paper set in a float coat of hot coal tar enamel was applied by machine. After this the pipe was covered with a light steel mesh, and then gunited to a thickness of 3in, to protect the bitumen from damage by barnacle settlement, to give mechanical protection against damage, and to give the pipe additional weight for sitting on the sea bed. To avoid the hazards of strong currents, rough seas and heavy surf, it was decided to launch the line along the sea bed. However, the protective coatings had increased the weight of the pipe from 50 lb to 120 lb per foot run so that it was impracticable to draw the line to sea in the normal manner. This difficulty of weight was overcome by strapping air pontoons to the pipe at intervals along its length so that the weight was reduced to 3lb per foot run. The pontoons, numbering 230, were made of ¼in steel plate formed into cylinders 36in in diameter by 60in long and attached to the pipe by two straps of 2in wide hoop iron. In order to release the pontoons, after the pipeline was in position, without sending divers down, each pontoon was fitted with two cutting devices through which the strap fastenings were passed. A light wire, running the entire length of the pipeline, was fastened to levers at each cutting device, then as the wire was pulled into the boat the strap fastenings were cut and the pontoons rose to the surface.

Two tugs, using a 9in manila hawser, towed the pipeline out to sea and in order to reduce launching friction special rocking cradles were used and set at 60ft centres. The cradles consisted of steel frames about 10ft long fitted at each end with three 24in diameter pneumatic-tyred wheels mounted in an arc on roller bearings. The centre wheel took the weight of the pipe while the outer wheels created leads which orientated the pipe and prevented it from moving off centre. The rocking frame enabled the cradles to adapt themselves to irregularities in the ground and as each string was towed out to sea the next string was lifted by crawler cranes on to the cradles and welded to the tail of the preceding string, the joint being wrapped and coated.

The launching operation was completed in ten days and was closely controlled by a 40-ton diesel powered back haul winch located at the rear of the pipe spread. A wire rope connected the winch to the rear of the pipe string and a torsion dynamometer indicated the pull of the pipe. The winch operator was in telephonic communication with a tower on the shore and this tower was similarly linked with points along the pipe string. Tug movements were controlled by short wave radio telephone. The contractor was Taylor Woodrow (West Africa), Ltd.

Air Compressor Set for Technical College

By DENIS J. RYLEY, M.Sc.(Eng.), A.M.I.Mech.E.*

THE choice of mechanical engineering equipment for technical colleges and university heat engines laboratories involves many conflicting factors. Thus, a piece of machinery must not be so large that it is costly to buy and run, nor should it be so small as to be regarded by the students as little better than a toy. It must be sufficiently robust to withstand rough handling and unskilled use, yet provide results which are representative of industrial practice. Finally, it must be safe to handle and not deteriorate during long enforced periods of idleness.

Attention has been given to all these factors in a new air compressor set now nearing completion in the steam laboratory in the Loughborough College of Technology. The general layout may be seen from the illustration. The set was installed under the writer's supervision, the fitting and erection being undertaken by senior students as part of their practical training for a diploma.

The compressor and air receiver were manufactured by Messrs. Alley and MacLellan, and are specially adapted for instructional purposes. Compression takes place in two stages, and 54 cubic feet of free air per minute are delivered at a maximum final gauge pressure of 100 lb per square inch. The compressor is electrically driven by a shunt wound d.c. torque reaction dynamometer of college manufacture, which delivers 16 h.p. at 1600 r.p.m. As the compressor speed is 300 r.p.m. the necessary speed reduction is accomplished by a vee belt drive which employs seven belts in parallel. Arrangements are included for enabling the compressor speed to be continuously variable below the maximum so as to enable the effects of throttling to be explored on the indicator diagrams.

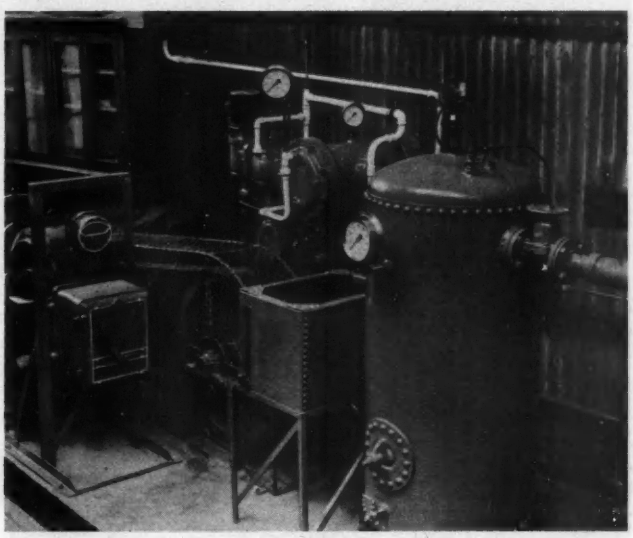
A surface type interstage cooler is provided, and cooling water is supplied via a constant head tank. On leaving the intercooler the water flows through the cylinder jackets before leaving the compressor, the whole system being equivalent to a contra-flow cooler. To enable a heat balance to be made, thermometers are suitably placed and exit water may be diverted at will into a measuring tank.

In order to assess the power input to the dynamometer, a voltmeter and ammeter are included in the supply line, while losses in the dynamometer itself may be determined if required by a standard electrical test method such as a Swinburne test. The total power output from the dynamometer may be assessed from the torque and speed, whilst the transmission losses must be estimated from the belt maker's specifications.

The compressor construction provides for access to both h.p. and l.p. compression spaces for the purpose of indicating. The indicator drive is taken from a rocking lever actuated by the connecting-rod. Using the indicator diagrams the air horsepower may be worked out and compared with the estimated compressor input to give by difference the mechanical and windage losses. It is hoped that the indicator diagrams themselves will provide a fund of visual information of which valve "bounce" or its absence may be quoted as an example. For the tutor or student skilled in draughtsmanship, the mean indices of the compression and re-expansion curves can be obtained in the usual way.

The compressor is provided with both hand and automatic unloading gear acting on a throttle valve in the air intake, whilst hand adjustment enables the pressure fall range to be varied.

To extend the possible scope of experimental work the receiver has been fitted with a discharge pipe containing an air orifice flange. The differential head is measured by a water manometer. For any given speed and governor setting, the weight discharge of air may be directly measured and compared with calculations based on the speed and l.p. cylinder dimensions. In this way, it will be possible to estimate the volumetric efficiency for comparison with the value obtained from the indicator diagram.



This air compressor set for Loughborough Technical College is specially arranged for testing by students

Finally, to provide advanced experiments, the receiver is so arranged that it can be charged and isolated. By opening a release valve the receiver is discharged and a bourdon gauge pointer can be timed during its descent, and

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the actual emptying time compared with the theoretical time calculated under suitable assumptions. To enable the emptying process to be analysed further, provision has been made for fitting a thermometer and a continuous indicator to the receiver. The pressure-time record obtained should demonstrate two regimes of discharge—those during which the pressure ratio across the orifice is respectively above and below the critical value for air.

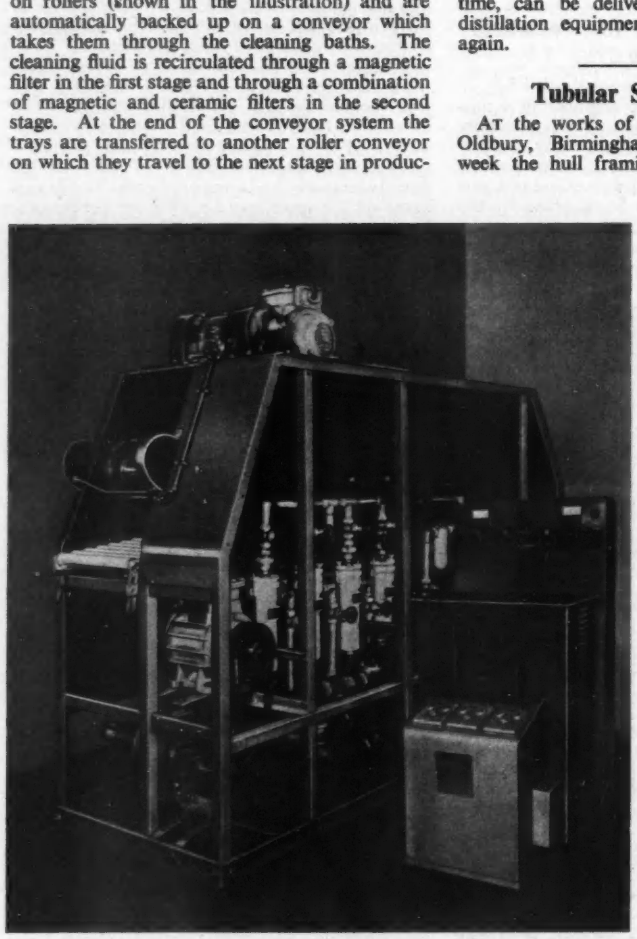
Following modern practice, all valves are rubber-seated, and the pipework is finish painted in accordance with the B.S.S. colour code.

It is considered that the equipment described will enable every standard experiment possible with reciprocating air compressors to be conducted and that it caters alike for the needs of elementary and advanced students. With very little extension it can be adapted for research.

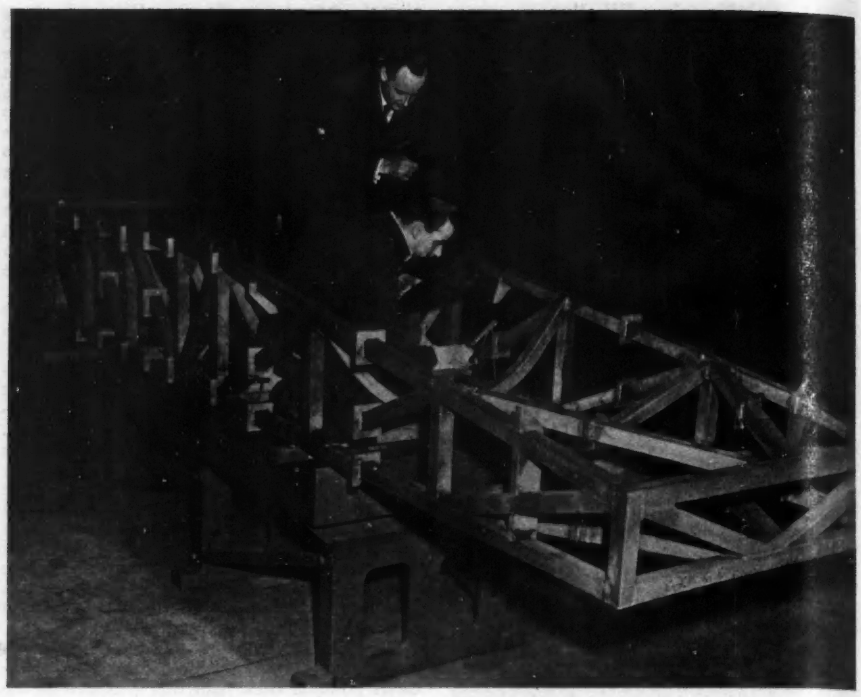
The writer is indebted to Messrs. R. B. Bruce and J. V. Skirrow, senior students, who erected the plant, for several helpful suggestions.

Ultrasonic Cleaning Plant

A 2½kW, 1 Mc/s ultrasonic cleaning plant which is fully automatic has been produced jointly by Ultrasonics, Ltd., Otley, Yorkshire, and Mullard, Ltd., Century House, Shaftesbury Avenue, London, W.C.2. A two-stage cleaning cycle is employed. The high frequency sound energy is supplied from the generator by means of barium titanate transducers. These synthetic crystals have the advantage over quartz of a low excitation voltage, which makes them suitable for operating in direct contact with the liquid. The maximum intensity is 5W per square centimetre. Such irradiation rapidly dislodges grease and foreign particles even from parts of the articles which are normally inaccessible ; the surfaces are stated to be made chemically clean to a degree unobtainable by conventional methods. The components are placed in open wire mesh trays. These run into the plant on rollers (shown in the illustration) and are automatically backed up on a conveyor which takes them through the cleaning baths. The cleaning fluid is recirculated through a magnetic filter in the first stage and through a combination of magnetic and ceramic filters in the second stage. At the end of the conveyor system the trays are transferred to another roller conveyor on which they travel to the next stage in production. The variable speed drive on the conveyor allows considerable latitude so that the plant can be run to match the speed of the production line. The cleaning fluid in the tanks can be removed simply by the operation of valves, and a new charge introduced. The fluid, which will become charged with oil in the course of time, can be delivered by the pumps to the distillation equipment so that it can be used again.



Ultrasonic cleaning plant. The roller conveyor, variable speed drive, pump unit and filters are on the left ; the ultrasonic generator is on the right



Final welding on the seamless tubular steel hull framework

Tubular Speedboat Hull

At the works of Accles and Pollock, Ltd., Oldbury, Birmingham, we were shown last week the hull framing for the boat in which Mr. D. Campbell hopes to regain the water speed record for Great Britain.

The hull, which is 24ft long, 3ft 8in wide and 2ft deep, is built from seamless steel tubes welded together. It contains 275ft of seamless tube—mostly 2in square section, 14 and 16 gauge—and a total welding run of about 200ft in approximately 250 separate welded joints. It represents, Mr. Campbell explained, an entirely new departure in design and one which might well show the way for a new constructional technique in future high-speed craft.

The hull is built from chrome-molybdenum seamless steel tube to British Standard Specification T.60—a 75-ton chrome-molybdenum steel tube suitable for welding. The specification demands, after hardening and tempering, tensile test figures for 0·2 per cent proof stress, of 68 tons per square inch minimum, 78 tons per square inch maximum ; and an ultimate tensile strength of 75 tons per square inch minimum, 85 tons per square inch maximum. After welding the ultimate tensile strength must be 50 tons per square inch minimum.

The technique for building these complicated structures was originally developed by Accles and Pollock, Ltd., for aircraft. It has since proved itself in racing car chassis and other applications where great strength coupled with lightness is demanded. Building a structure of this kind with so many welded joints, called for considerable experience because the heat involved in the welding process tends to cause distortion of the frame members, and requires a special sequence of operations to avoid it.

Mr. Campbell stated that he hoped to have the boat ready for trials—probably on Ullswater—later this year. Electronic transmitting instruments would be fitted in the boat so that stresses measured at various points on the hull would be recorded and transmitted to the shore where they would be monitored. He referred to the problem of the high stresses which caused the late John Cobb to lose his life two years ago when travelling at over 200 m.p.h. A very careful study had been made of the films and photographs of Cobb's boat up to the moment of its disintegration and the information gained had been most valuable.

The framework is shown in the illustration above ; it weighs 580 lb and the complete boat, it is claimed, will weigh less than any other boat of a similar kind. Mr. Campbell stated, however, that it would have five times the strength of the old "Bluebird" and it would be three times stronger than Cobb's "Crusader." It has been tested in the vertical plane to a factor of 27 *g* and will be powered by a Metropolitan Vickers "Beryl" straight turbo-jet engine of 4000 lb static thrust. In a model test programme Mr. Campbell stated that many tests up to 100 m.p.h. had been undertaken.

Setting Up a Subsidiary in Canada.—The Board of Trade has produced a pamphlet for the guidance of those firms who may be considering setting up a subsidiary organisation in Canada. It makes no claim to be more than an introduction to the subject, but it touches on most of the important factors which have to be taken into account, such as, for example, application to the Bank of England and Treasury ; the difference between Dominion and Provincial registration ; solicitors' fees and fees for incorporation ; selection of a name ; and Federal, Provincial and other taxation. It includes an appendix listing useful contacts in the Provinces of Canada. The pamphlet will be sent free on request to the Board of Trade, Commercial Relations and Exports Department, Room 4170, Horse Guards Avenue, London, S.W.1.

The American Scene

(By Our American Editor)

A Rotary Metal Forming Process

An unusual metal forming method, known as the "Floturn" process, has been developed by the Lodge and Shipley Company, of Cincinnati, Ohio. The process forms metal with the aid of considerable pressure which is applied to cause the metal to flow in a cold state. Using a hardened and polished roller, the pressure is applied in a continuous spiral, thus causing the gradual and accurate flowing of a metal blank to take the shape of an internal mandrel. Conical, cylindrical and other complex shapes may easily be formed by the process. The forming operation usually starts with a simple flat blank, a machined blank, a machined forging, a drawn cup, a wrapped and welded cylinder, or a centrifugal casting. In many cases the parts can be produced with a single pass directly to the finished dimensions. In other cases, where extreme precision is necessary, 0·015in to 0·020in may be left for final machining. The accompanying illustrations show the Lodge and Shipley No. 40 "Floturn" lathe being used to form an exhaust cone for an aircraft jet engine. This particular cone had a finished wall thickness of 0·027in ±0·002in and was made from a 21in by 21in by 0·095in blank of stainless steel conforming to the American "AMS-5510" specification.

The company points out that the new method differs considerably from the conventional spinning method. In spinning, a blank considerably larger than the finished piece is used. Employing moderate pressure, the blank is merely folded in a circular manner, using a hard tool against a round mould. This manual art requires a craftsman of considerable skill and experience and, in general, the parts produced into the extended shape. The machine fully controls the operations so that no particular skill is required of the operator. All the pieces produced are uniform; dimensions can be held to ±0·002in.

The new process has already been widely tested and used in aircraft jet engine production where it has found an important time and money-saving application. Among the metals and alloys which have been successfully formed are the austenitic and ferritic stainless steels, the Timken 16 Cr–25 Ni–6 Mo "superalloy," the Haynes Stellite "Multimet" cobalt-base alloy, the Universal-Cyclops "Uniloy" 19 Cr–9 Ni heat-resistant steel, the "Inconel," "Inconel X," "Monel" and "K-Monel" nickel-base alloys, the "Ti-140 A" two-phase, high strength, titanium-base alloy, copper, aluminium, as well as mild steel. The existing equipment used in the application of the process can handle work up to 42in in diameter and 50in in length. It has been found that blanks of the harder metals may be worked up to $\frac{1}{16}$in in thickness, while those of the softer metals may be worked up to $\frac{1}{2}$in in thickness.

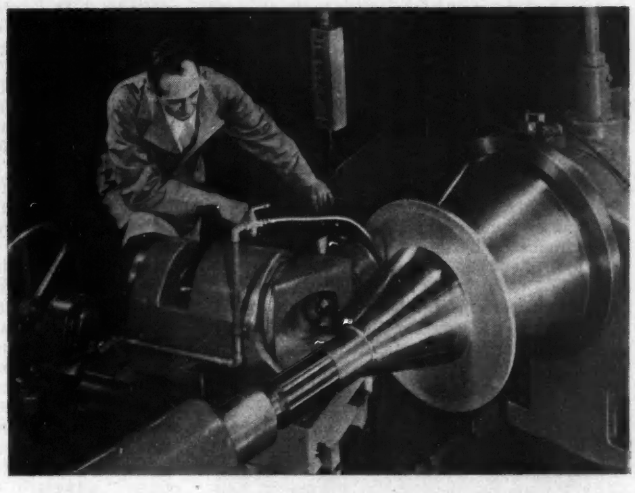


Fig. 2—Roll forming of jet engine exhaust cone on "Floturn" lathe

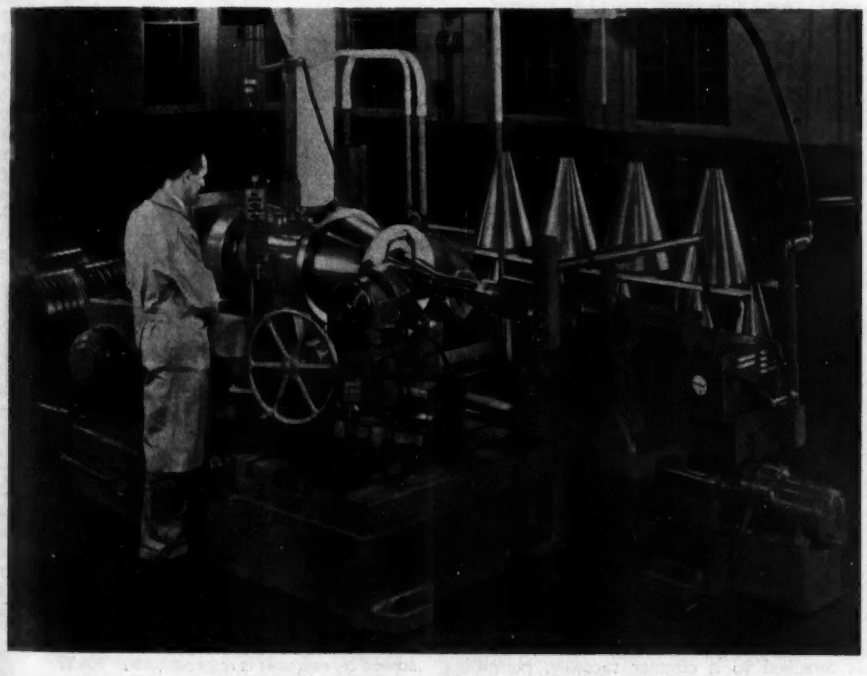


Fig. 1—Lodge and Shipley "Floturn" metal forming lathe

lack uniformity. In the case of the "Floturn" process the diameter of the blank is exactly that of the finished part. The initial blank thickness is heavier than that required in the finished wall, and the additional metal flows

An important advantage of the process is the fact that the forming method actually increases the strength and hardness of the metal worked. In direct contrast to the stresses developed in a process such as deep drawing, the "Floturn" method has a beneficial effect similar to cold rolling on the grain structure of the metal. In a representative example, involving the working of 18-8 stainless steel, tests showed that the process increased the tensile strength by as much as 100 per cent. Even after subsequent stress relieving, the increase still amounted to about 40 per cent. The superficial hardness of the component increased from the original annealed state to between 57 and 59, on the Rockwell "30N" scale. By combining machining with the forming operation, it is possible to produce parts of a shape which was considered impractical before. In almost every case the finished part has been found to be stronger than if produced by other methods because the lines of grain flow within the metal remain unbroken.

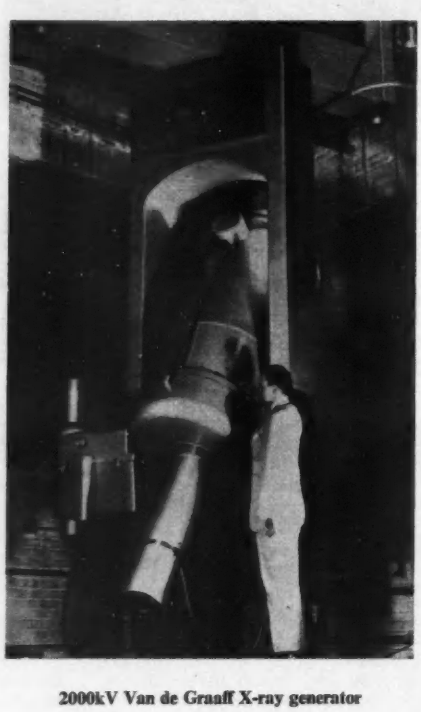
Large Intermittent Wind Tunnel

A contract for the design and development of a large wind tunnel has been placed by North American Aviation, Incorporated, of Los Angeles, with the Pittsburgh-Des-Moines Steel Company, of Pittsburgh. The test facility has been called a "tri-sonic" wind tunnel as it will be used in the testing of advanced aircraft designs at speeds slower, equal to and faster than that of sound. It is claimed that the test facility will be the largest intermittent, blow-down tunnel in the United States. High wind speeds will be produced by compressed air flowing from a series of large storage spheres at selected intervals, and it is expected that each test will be less than a minute in duration. Three internal structures will provide an effective control over the test speeds. An adjustable nozzle, a transonic chamber and a variable diffuser will be placed in series in the throat of the tunnel to regulate the air speeds at subsonic, transonic and supersonic levels. The test chamber of the tunnel will be able to handle an aircraft or missile model with a wing span of about 4ft. The chamber will be 17ft long and 7ft square. Other tunnels with similar speed ranges now operate in America with a continuous flow of air, but their construction costs are several times greater than that for the intermittent design chosen by the company.

Fabrication of Pressure Vessels

THE Foster Wheeler Corporation, of New York, recently put into operation at Mountaintop, Pennsylvania, one of the most modern American works for the fabrication of steam drums and pressure vessels for use in the power generating, petroleum and process industries. The new works are intended to augment the other manufacturing facilities of the company at Carteret, New Jersey ; Dansville, New York, and St. Catharines, Ontario. Planned to produce cylinders of varying proportions, from conventional sizes to the largest and heaviest, the factory includes many fabricating tools designed by the firm's engineering department to meet certain special requirements.

One of the major tools is an 8000-ton beam press weighing over 3,000,000 lb. The press was built by the Baldwin-Lima-Hamilton Corporation and is said to be one of the largest of its kind ever made. It can bend hot steel plate up to 8in thick, and can handle lengths up to 40ft. The press is hydraulically operated, control of the speed of the moving beam being at the discretion of one operator. Such control is accomplished by means of a single lever, the position of which determines the speed and direction of motion. This control is effected by a mechanical linkage between the operator's lever and four " Oilgear " reversible pumps, which are coupled to two 200 h.p. double-end



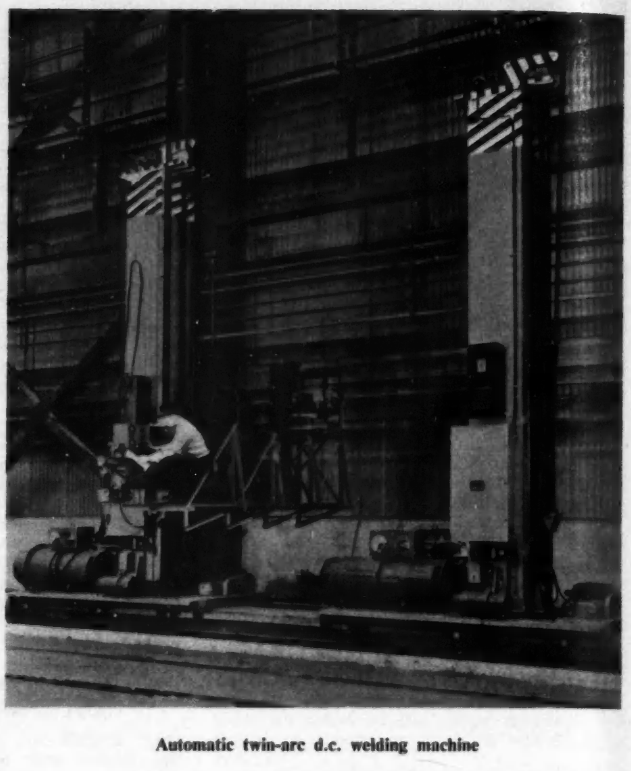
2000kV Van de Graaff X-ray generator

motors. The press structure occupies a surface area of 65ft by 20ft and combines two individual 4000-ton, four-column presses within one framework. The two sets of columns are coupled together by laminated steel beams, one set being attached to the bottom platen and one to the moving platen. This arrangement results in a single unit capable of exerting loads up to 8000 tons on the plate to be formed. Each of the 4000-ton sections consists of a cast steel main cylinder, a moving platen, pushback cylinders, and equaliser cylinders. The columns are shoulderless and of a " straight-through " design that permits the removal of any one of them without completely dismantling the press. The steel columns are assembled to the main cylinder by means of split cast steel nuts at the lower extremities and split steel collars set into a counterbore in the upper surface of the bottom platens. In this way, any of the columns may be removed by drawing them up through the main cylinder column husks. The presses are designed to provide daylight of 96in maximum between the lower surface of the upper bending beam and the upper surface of the lower bending beam. All rams have a maximum stroke of 60in. The maximum operating speed in either direction under no-load conditions is 82in per minute ; the maximum pressing speed is 12in per minute at a load of up to 8000 tons.

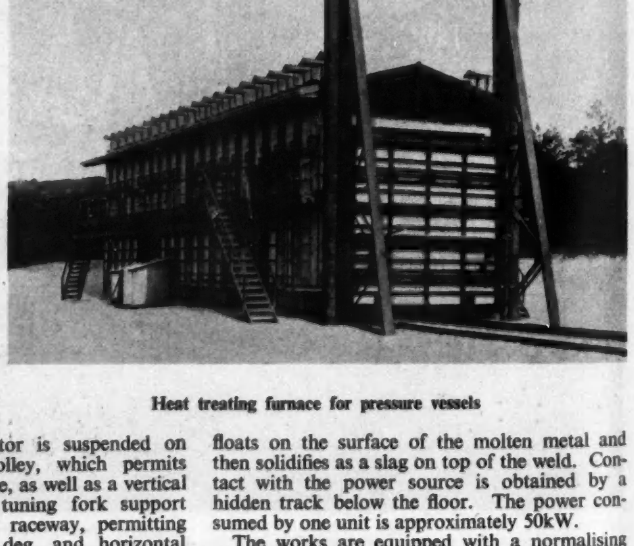
To facilitate the handling of the hot steel plate there has been installed a plate handling device which positions the plate to be formed easily and with a minimum loss of metal temperature. This plate-joggling mechanism will handle plates weighing up to 40 tons each. It consists of four 7in diameter lift cylinders, eight 3½in diameter manipulating cylinders, rollers, push rods and pins. The push rods are hinged to facilitate back-and-forth movement in a vertical plane, and the vertical strokes of these rods is 13½in. The lifting pins have a horizontal movement of 3in to either side of the vertical centre line. The positioning toggles, which are hydraulically operated, are built into the lower press beam. The device is operated by means of a " Vickers " oil-hydraulic system having a capacity of 7 gallons per minute at 2000 lb. per square inch.

An outstanding item of equipment in the new works is a 2000kV Van de Graaff X-ray generator capable of penetrating steel thicknesses up to 12in and photographing weld metal to detect flaws, holes or scale that may form in such material. The unit, which is shown in the accompanying illustration, is the first X-ray generator of its kind to be installed in America for purposes of industrial radiography. It is housed in a structure of concrete and steel, with walls 4ft thick that rise 35ft on the side opposite the main plant, and 25ft on the remaining three sides. There is also an additional rise of 15ft to the roof-top, to accommodate two overhead cranes for handling the material to be examined and for manœuvring the X-ray machine. In the interest of safety, the building has been erected at a distance of 550ft from the main plant. The generator is suspended on tracks from a crane trolley, which permits travel over the X-ray house, as well as a vertical movement of 24ft. The tuning fork support is attached to a circular raceway, permitting vertical rotation of 180 deg. and horizontal rotation of 360 deg. The machine is operated from a desk console in a separate room. It was made by the High Voltage Engineering Corporation, Cambridge, Massachusetts.

The works employ several automatic welding machines utilising the twin-arc d.c. " Lincoln-weld " method of shielded arc welding. The welding machines, one of which is illustrated, have bases which can be adjusted to take vessels up to 12ft in diameter and which travel on a track 150ft long. The units employ means of automatic flux recovery and power-driven booms which are controlled at the operator's station. Prior to welding, granular flux is deposited on the joint to be welded, deep enough to cover the completed weld. Bare metallic welding electrodes in tandem are then fed into the blanket of flux at rates of feed controlled automatically to obtain proper arc length. On welding, the flux adjacent to the arc melts, floats on the surface of the molten metal and then solidifies as a slag on top of the weld. Contact with the power source is obtained by a hidden track below the floor. The power consumed by one unit is approximately 50kW.



Automatic twin-arc d.c. welding machine



Heat treating furnace for pressure vessels

The works are equipped with a normalising furnace capable of reaching 2100 deg. Fah., with inside dimensions of 45ft by 16ft by 7ft high. The accompanying illustration shows a propane-gas-fired heat-treating furnace, in which pressure vessels may be stress-relieved at temperatures ranging up to 2100 deg. Fah. Its interior dimensions are 15ft by 83ft by 14ft high, but an expandable rear wall permits the treating of vessels longer than 83ft.

Industrial and Labour Notes

Overseas Trade

The Board of Trade has now issued the final figures relating to the United Kingdom's overseas trade in June and in the first six months of this year. The figures show that in June, which contained only twenty-four working days, the value of exports of United Kingdom goods amounted to £217,700,000. In the second quarter the value of exports was slightly less than in the first quarter, when there were three more working days, but, the Board of Trade says, the level of exports has remained fairly steady since the beginning of the year. The monthly average value of exports in the first six months of this year was £224,000,000, which was 7 per cent above the average for the first half of last year. Prices so far this year, however, have averaged about 1 per cent less than in the comparable period of 1953, and the volume of exports has been about 8 per cent more.

The United Kingdom's overseas trade this year has been characterised by an increase in the value of exports of engineering products; in the first six months of this year engineering exports averaged £86,500,000 a month, which was £6,000,000 a month more than in 1953. The improvement in engineering exports was mainly in road vehicles, the value of which in the first half of this year averaged £23,500,000. Exports of motor cars and chassis averaged over £10,000,000 a month, the principal markets being Australia, New Zealand and Sweden. Exports of commercial vehicles rose to £2,500,000 a month and of commercial vehicle chassis to £3,500,000 a month. The second biggest improvement in engineering exports in the first half of this year was in the non-electric machinery division, where an increase of about £2,000,000 a month, compared with a year ago, brought the monthly average value to nearly £35,500,000. Shipments were higher in most categories of goods, but particularly in wheeled and track-laying tractors, which averaged £4,000,000 a month. Tractor exports to the U.S.A. and Australia were higher but were offset by reduced shipments to Sweden. Exports of aircraft engines also increased in the first six months of this year, but overseas sales of textile machinery and machine tools declined. Other categories in which increased exports were reported were railway vehicles, ships and boats, and scientific instruments. In exports of electrical machinery there was little change during the first six months of the year, compared with corresponding months of 1953. The monthly average value in this class was £14,700,000. Exports of metals totalled £28,000,000 a month in the first half of this year, which was slightly more than in the corresponding period of last year, but 3 per cent below the rate in the latter half of 1953.

Engineering Wages

This week the Confederation of Shipbuilding and Engineering Unions has issued the agenda for its annual conference, which is to be held at Brighton from August 10th to 13th. Many of the resolutions set out in the agenda are concerned with wages matters, but only two of them advocate negotiations for a new wages structure on the lines of that formulated by the Confederation in 1949. One of these resolutions, submitted by the Amalgamated Engineering Union, calls for the adoption of the new wages structure, "with the wage scales suitably amended," and urges that this matter should now be considered by the Confederation's executive as a "first priority."

Among the other resolutions on wages is one from the Amalgamated Union of Foundry Workers, which expresses concern that "over a period of years wage increases have not overtaken prices," and that since the last increase the cost of living has continued to rise. This resolution calls upon the Confederation's executive "to formulate a wage policy conforming to the needs of our union membership." A resolution submitted by the National Union of Vehicle Builders asserts that minimum rates in the current engineering wages agreement are low in relation to those in other industries, and asks that an "immediate application" be made to the engineering employers for an increase of 10 per cent on all consolidated time rates, and that the basis for fixing piecework prices should be 65 per cent. Yet another resolution, formulated by the Electrical Trades Union, demands "an immediate application for a further substantial increase in wages in both the engineering and shipbuilding industries." A resolution submitted by the Transport and General Workers Union notes "the concern and discontent created by the long-drawn out discussions on wage claims," and urges the Confederation's executive council "to take more positive action in future by using quickly the machinery already available for the settlement of such questions." Finally, there is a resolution from the United Patternmakers' Association expressing opposition to any proposal made for the appointment of a Royal Commission to consider wages in relation to the national economy. This resolution also expresses opposition to "development of the arbitration machinery or the proposal of the Court of Inquiry into the engineering and shipbuilding disputes that there should be an authoritative and impartial inquiry into wage demands."

Among the other resolutions to come before the conference, there are three relating to the nationalisation of parts of the engineering industry. A scheme for nationalisation, entitled *Plan for Engineering*, was approved by the Confederation a few years ago. One of the forthcoming resolutions regrets that the Trades Union Congress does not wholly support the nationalisation plan. Another resolution, submitted by the Amalgamated Engineering Union, expresses the view that the "national plan for the engineering industry" is still important to the community at large and the national economy as a whole. The Confederation's executive council is therefore urged "to give further publicity to this plan and do all in its power to speed its implementation."

Ministry of Labour's Annual Report

The annual report of the Ministry of Labour and National Service for 1953 was published last week. It says that the year was a good one for employment, the total working population in November last being over 23,500,000, which was the highest peacetime figure ever recorded. As a result of a revival in trade there were more people at work and fewer unemployed than in 1952, more overtime was worked and less short time, and productivity increased. The report notes that of the 6 per cent increase in the total wages and salaries bill in 1953, about two-thirds appears to have been due to higher rates of pay resulting mainly from settlements reached towards the end of 1952. Weekly rates of wages rose by about 3 per cent during the year, compared with 6 per cent in 1952 and 11 per cent in 1951.

The report includes a survey of the manpower position in various industries and services. On the whole, it is stated, the labour position last year in the basic industries of coal mining, transport and agriculture was satisfactory. In the manufacturing industries the position was equally satisfactory. The general level of unemployment during the year was considerably lower than that of 1952, a factor which is attributed mainly to the trade recovery in the textile industries. About industrial disputes, the report says that 2,169,000 working days were lost in 1953 through stoppages of work resulting from industrial disputes. Had it not have been for the one-day token strike last December in the engineering and shipbuilding industries, however, the total number of days lost through disputes would have been the lowest since 1941. Of last year's total of days lost, the stoppage in the engineering and shipbuilding industries accounted for 1,050,000 days. The report adds that, whilst the coal mining industry again accounted for a high proportion of the stoppages through disputes, the actual number of working days lost showed a substantial reduction compared with 1952, the figures being 395,000 days last year and 660,000 in 1952.

In a chapter surveying personnel management and joint consultation, the report says that throughout last year there was increasing public interest in the subject of good human relations in industry. Furthermore, there was growing recognition of the fact that the problem of effective consultation and communication between management and employees is of particular national concern. The Ministry's personnel management advisers extended their services to small and medium-sized industrial organisations without specialist personnel officers. Altogether, these advisers paid about 3000 visits to firms of all kinds and sizes. In addition, grants were made by the Ministry, from funds derived from United States economic aid, for work in the field of human relations by various academic and voluntary bodies and by some employers' organisations.

Human Relations in Industry

The function of the Minister of Labour's National Joint Advisory Council is to advise the Government on matters in which employers and workers have a common interest. Some time ago the Council set up a sub-committee to examine the problems concerned with human relations in industry, and this committee has now submitted a report in which various recommendations are made.

The sub-committee's main recommendation is that steps should be taken to draw the attention of employers and workpeople to the need for a conscious and positive effort on their part to maintain and improve sound relations in individual firms or establishments. The committee considers that employers' organisations, nationalised industries and trade unions can all help in this respect, and urges that "they increase those of their activities and services which will assist the development of sound relations." It also urges that the attention of these organisations should be drawn to "the work of professional and other associations working in the field with a view to their offering encouragement and support to those activities which appear to be helpful." In making these recommendations, the committee has concluded that the hard facts of the country's economic and trading position are still not sufficiently understood in industry, and that the differing circumstances of each firm within an industry are even less understood. The remedy, the committee thinks, does not lie solely within individual firms, and it calls, amongst other matters, for "much greater clarity and consistency in Government pronouncements on the subject." The committee does feel, however, that a great deal more can be done on the shop floor. Its report says that responsibility for achieving good relations rests first on employers. But their efforts, the report continues, may be frustrated unless the workpeople understand that any increase in their own real income depends on an increase in the prosperity of the country as a whole, and that an increase in the efficiency and prosperity of their own firms is an essential contribution to that prosperity. Employers equally, it is added, must accept the same obligation and must recognise that the efficiency and prosperity of their industries are not merely their own concern, but are a matter of national interest.

The sub-committee's conclusions and recommendations are set out in a leaflet which is being circulated by the Ministry of Labour to employers' organisations, trade unions, nationalised industries, industrial and professional associations and other agencies. The leaflet says that the committee's conclusions are a challenge to the Government, to employers and to workers alike, and that good industrial relations in this country are built on good faith and mutual respect between employers' and workers' organisations.

Notes and Memoranda

Air and Water

INTERNATIONAL MEETING.—An international meeting on "Technique of Ships and Navigation" is to be held in Naples from September 26th to October 1st, at which papers are to be read by Italian, French, German, Spanish, Egyptian and British authors.

COMPLETION OF "IBERIA."—The P. and O. liner "Iberia," which was launched on January 21st, and is a sister ship to the "Arcadia" commissioned earlier this year, is at present being completed by Harland and Wolff, Ltd., at Belfast. The ship has a length overall of 718ft 6in, a breadth moulded of 90ft 6in, a service speed of 22½ knots, and will carry 674 first-class and 733 tourist-class passengers. It is expected that trials will take place early in September and that the liner will sail from London on September 28th on her maiden voyage, via Port Said, Aden, Bombay, Colombo, to Australia.

COMBINED B.E.A. AND K.L.M. LONDON/AMSTERDAM SERVICE.—British European Airways and K.L.M. Royal Dutch Airlines are to operate a combined air service between London and Amsterdam with effect from October 3, 1954, an agreement having been signed to operate the services jointly in pool. From October 3rd till October 30th, the joint frequencies between London and Amsterdam will amount to seven per day; from October 31st, six return flights will be operated, whereas during the summer service 1955, it is the intention to increase this number to nine services per day in both directions. Night mail and freighter services are not included in these numbers.

RUSSIAN SHIPBUILDING ORDERS.—A question addressed in Parliament last week to the First Lord of the Admiralty asked what steps were being taken to encourage British shipbuilders to seek orders in the U.S.S.R. and Eastern Europe. The Civil Lord of the Admiralty, Mr. Wingfield Digby, who replied, said that he had been in constant touch both with the Shipbuilding Conference and with individual shipbuilders on the subject. Certain shipbuilders had visited Moscow and were now negotiating with the U.S.S.R. for contracts for merchant shipping. The Civil Lord added that discussions on Russian requirements as a whole had recently taken place in London between the shipbuilding industry and the Russian trade delegation.

MR. H. E. SHEARDOWN.—It is with regret that we record the death of Mr. H. E. Sheardown, which occurred at Beverley last week. Mr. Sheardown, who was seventy-two years of age, and a native of Hull, served his apprenticeship with Charles D. Holmes and Co., Ltd., the marine engineers of Hull, a firm of which he was later to become a director and chairman. He was the chairman of Cook, Welton and Gemmell, Ltd., of the Humber Brass and Copper Works Company, Ltd., and of Turner and Sellars, Ltd., and also served on the boards of the Kingston Steam Trawling Company, Ltd., and other companies. Mr. Sheardown, who was awarded the C.B.E. last year, was the chairman of the National Association of Marine Engine Builders in 1947, and a member of the General and Technical Committees of Lloyd's Register of Shipping.

NAVAL ARCHITECTS' AUTUMN MEETING.—The autumn meeting of the Institution of Naval Architects is to be held at Torquay from September 21st to 24th. The following is the programme of papers:—Tuesday afternoon, September 21st, "The Admiralty Experiment Works, Haslar," by Dr. R. W. L. Gawn, O.B.E., D.Sc.; and "B.S.R.A. Resistance Experiments on the 'Lucy Ashton,': Part III—The Ship Model Correlation for the Shaft Appendage Conditions," by Mr. H. Lackenby, M.Sc.; Wednesday morning, September 22nd, "The Measurement of Power," by Dr. T. W. F. Brown, D.Sc.; and "Scale Effect Experiments on Victory Ships and Models," by Professor Dr.-Ir. W. P. A. van Lammeren; Firday morning, September 24th, "Experiments with a Low Drag Hydrofoil," by Mr. R. L. Townsin, B.Sc.; and "Side Launching of Ships with Special Reference to Trawlers," by Mr. D. J. Doust, B.Sc.

Miscellanea

OFF-SHORE WELL.—An off-shore well has been "spudded-in" off the south-west coast of Trinidad in the Gulf of Paria by Trinidad Northern Areas, Ltd. The drilling rig is capable of attaining a depth of 6300ft.

BRITISH ELECTRICAL POWER CONVENTION.—The council of the British Electrical Power Convention has decided that its next convention will be held during the week commencing June 27, 1955, at Brighton, instead of at Margate as announced at the annual general meeting of the convention last month.

FIFTH CONGRESS ON LARGE DAMS.—The fifth congress on large dams is to be held in Paris from May 31 to June 4, 1955. The French national committee has now published the first bulletin relating to the congress, in which details are given of the study tours in France and North Africa, which will follow the technical sessions in Paris. The various technical "questions" of the congress were listed in an announcement of our issue of March 19th last.

ROGERSTONE POWER STATION.—The British Electricity Authority has received the consent of the Minister of Fuel and Power to the establishment of a new power station at Rogerstone, Monmouthshire. The station will have an installed capacity of 120MW, made up of two 60MW turbo-generators, each served by a boiler unit having an evaporative capacity of 550,000 lb of steam an hour. The authorisation includes the construction of two cooling towers, each having a capacity of 2,250,000 gallons of water an hour.

BUILDING IN CONCRETE.—An exhibition of photographs showing the architectural development of concrete and its use in building and civil engineering is to be held at the Royal Institute of British Architects, 66, Portland Place, W.1, from October 21st to 30th. As well as photographs from this country, a great deal of material has been collected from abroad and in particular there are to be included a number of photographs of Italian and Swiss buildings. Most of the photographs shown will be of buildings designed during the last two decades, but there will also be a section dealing with the early development of this material.

COAL OUTPUT.—The effect of the annual holiday season is now being shown in the figures for deep-mined coal production. Last week the output from the mines in Great Britain was 3,342,000 tons and from opencast workings 220,500 tons, making a total of 3,562,500 tons. This total was, however, 300,000 tons above that for the comparable week of last year. In the first twenty-nine weeks of this year coal output totalled 127,746,900 tons, compared with 126,154,900 tons in the corresponding period of last year. On July 17th, distributed stocks of coal amounted to 15,158,000 tons, as against 15,317,000 tons on the corresponding date last year.

ENGINEERS' GUILD AND EDINBURGH FESTIVAL.—The Scottish branch of the Engineers' Guild is extending an invitation to fellow members who may be visiting Edinburgh during the Festival of Music and Drama. To avoid interference with visitors' plans the welcome will be informal and flexible, consisting of a cocktail party on Monday, August 30th, and visits to works and engineering plants during the Festival. Members of the Guild who expect to be in Edinburgh between August 22nd and September 11th are asked to communicate with Mr. C. M. Beckett, 8, House o' Hill Row, Edinburgh, 4 (Edinburgh 77785), so that details of the arrangements may be sent to them.

OBITUARY.—We have learned with regret of the death of Mr. J. W. Baillie, formerly managing director of Horseley Bridge and Thomas Piggott, Ltd., which occurred on July 14th. Mr. Baillie joined the company in 1919 and retired from the office of managing director last December. He was, for some years, president of the British Constructional Steelwork Association, and, up to the time of his death, served on the grand council of the Federation of British Industries. We regret to record also the death of Mr. W. H. Seal, joint managing director of Ham, Baker and Co., Ltd., which occurred on July 19th. Mr. Seal was seventy-three and had completed fifty-nine years' service with his company.

HEAVY WATER AND POWER PROJECT IN NEW ZEALAND.—We learn that, in view of prospects of utilising heavy water in certain types of nuclear power reactors, the United Kingdom and New Zealand Governments have agreed to proceed with a project for producing heavy water and power from geo-thermal steam in the Wairakei District of North Island. Last year the United Kingdom decided on economic grounds not to go ahead with a project which was then under consideration, but the liaison in this field has been maintained. The plans at present under examination provide for a useful contribution to North Island's electricity supply and for subsequent extension of the plant should this prove desirable.

INDUSTRIAL FOOTWEAR.—The industrial safety division of the Royal Society for the Prevention of Accidents is organising a "National Industrial Foot Safety Week" from October 25th to 30th. The prime object is to encourage factory workers to wear suitable footwear while at work. The Society says that the general attitude of most workers is that their old shoes are good enough for work, and that the idea of buying footwear specially for work appeals to very few. As a result, the Society observes, no less than one-quarter of all industrial accidents cause injury to the feet or toes, and the sum total of human suffering, the loss of earnings to the worker and the loss of production to the country place a heavy burden on the national economy. The Society emphasises that this campaign will not try to encourage all workers to wear a particular class of footwear, but it will encourage the wearing of the right kind for the particular job being done. The campaign will also stress the importance of keeping all footwear in a good state of repair.

COAL UNDER ARBURY HALL.—The Minister of Housing and Local Government, after consulting the Minister of Fuel and Power, has decided that coal shall not be worked under about 36 acres of land, in the centre of which stands Arbury Hall, Nuneaton, a building which is listed as being of special architectural and historic interest. The Minister's decision follows a local inquiry held at Nuneaton in January, at which the National Coal Board sought permission to work two out of four seams in a pillar of coal underlying the land. It was stated on behalf of the Board that the coal in the two seams it was proposed to work was of the highest quality; on the other hand, the need to avoid damage to Arbury Hall was recognised. The Board had, therefore, prepared careful plans for a special method of working designed to minimise the risk of damage, and considered that if these plans were followed the building should settle evenly and without undue strain and that the effects of mining the coal, either on the structure of the building or on its internal decoration, would be negligible. The application was supported by the National Union of Mineworkers. In a statement read at the inquiry, Arbury Hall was described by the Minister's Advisory Committee on Buildings of Special Architectural and Historic Interest as the finest and most complete example of eighteenth century Gothic decoration in the country, its most notable element being the vaulted ceilings with elaborate plaster ribs and tracery.

Personal and Business

MR. J. R. GREENWOOD has joined the board of Associated Commercial Vehicles, Ltd.

MR. L. C. W. TURNER has been appointed sales director of Brush Electrical Engineering Company, Ltd., Loughborough.

MR. J. R. T. GIBSON JARVIE and Mr. Duncan Carmichael have been appointed joint managing directors of United Dominions Trust, Ltd.

CROFTS ENGINEERS (HOLDINGS), Ltd., Thornbury, Bradford, has acquired the whole of the share capital of J. Parkinson and Son, Shipley, Yorks.

MR. C. P. STORR, M.I.Mech.E., M.I.E.E., has been appointed manager of the Dominions division of Metropolitan-Vickers Electrical Export Company, Ltd.

THE JOHN THOMPSON group of companies has opened a new branch office, for the North of England, at Ravenswood, Westfield Lane, Ryton-on-Tyne, Co. Durham.

JOHN BROWN AND CO., Ltd., announces that it has acquired from A. C. Wickman (Canada), Ltd., the business and assets relating to the manufacture of tungsten carbide equipment and its business as agent and factor of machine tools.

B. AND S. MASSEY, Ltd., Openshaw, Manchester, states that Mr. R. M. Tyrrell has been appointed to take charge of its London office at 131, Victoria Street, S.W.1. This follows the retirement, owing to ill-health, of Mr. G. M. Turnbull, who will, however, continue to represent the firm in S.W. England.

THE GENERAL ELECTRIC COMPANY, Ltd., states that Mr. J. B. Taylor, manager of the Leicester branch, has been appointed managing director of British General Electric Company (Canadian), Ltd., in succession to Mr. J. S. Langlands, who becomes district assistant manager of the G.E.C. in Scotland. Mr. K. L. V. Nichols, of the Ipswich branch, has been appointed manager of the Leicester branch.

THE MACFARLANE ENGINEERING COMPANY, Ltd., Cathcart, Glasgow, states that Mr. J. C. Macfarlane has retired from the position of managing director, but will continue as chairman of the company. Dr. J. W. Macfarlane has been appointed managing director, Mr. C. C. Macfarlane becomes an additional director, and Mr. A. W. Muir has been appointed secretary. Mr. W. I. Macfarlane continues as a director, with responsibility for electrical design.

J. AND E. HALL, Ltd., Dartford, Kent, announces an amalgamation with Linde Canadian Refrigeration Company, Ltd., Montreal, Canada. The refrigeration business will operate in Canada under the title of the Linde Hall Canadian Refrigeration Division of J. and E. Hall, Ltd., with Mr. J. H. C. McGarry as manager. The address of the division is 5031, Cote de Liesse Road, Montreal. The Canadian escalator and elevator branch of J. and E. Hall, Ltd., will continue at 267, Davenport Road, Toronto, under Mr. E. B. Rook.

Launches and Trial Trips

PLAGIOLA, bitumen carrier; built by Deutsche Werft, Hamburg, for Shell Tankers, Ltd.; length between perpendiculars 505ft, breadth moulded 66ft 6in, depth moulded 38ft, deadweight 15,000 tons, draught 28ft 9in; speed 14¼ knots; ten cargo tanks, one pump room, two 500 tons per hour cargo pumps; one set of geared, compound, impulse turbines, 6000 s.h.p. service power, 6600 s.h.p. maximum power, steam supplied at 500 lb per square inch and 800 deg. Fah. by two Babcock and Wilcox water-tube boilers. Launch, July 12th.

SOLSTEN, oil tanker; built by Barclay Curle and Co. Ltd., for Rafen and Loennechen, Norway; length 528ft, breadth 65ft 6in, depth 37ft 6in, deadweight 15,400 tons; two pump rooms, steam deck machinery, two 75kW steam-driven dynamos, one 25kW diesel-driven generator; Barclay Curle-Doxford oil engine, five cylinders, 670mm diameter by 2320mm combined stroke, two cylindrical multi-tubular boilers. Trial, July 13th.

BEECHMORE, cargo liner; built by the Burntisland Shipbuilding Company, Ltd., for Johnson Warren Lines, Ltd.; length between perpendiculars 345ft, breadth 52ft 7in, depth moulded to shelter deck 32ft 4in, deadweight 4950 tons, draught loaded 21ft 10in; twelve passengers; four cargo holds, one 25-ton, ten 5-ton and two 10-ton derricks, steam-driven deck machinery; Hawthorn-Doxford oil engine, four cylinders, 600mm diameter by 2320mm combined stroke, 3300 b.h.p. Launch, July 15th.

HUNTSLAND, cargo ship; built by the Burntisland Shipbuilding Company, Ltd., for the Power Steamship Company, Ltd.; length between perpendiculars 450ft, breadth 64ft, depth moulded to shelter deck 40ft 5in, deadweight 11,750 tons, draught loaded 27ft 1½in; five cargo holds, one 50-ton, one 40-ton, four 10-ton and six 5-ton derricks, electrical deck machinery; Hawthorn-Doxford oil engine, six cylinders, 670mm diameter by 2320mm combined stroke, 6600 b.h.p. Trial, July 16th.

ANDWI, oil tanker; built by John Crown and Sons, Ltd., for Rolf Wigand Skipsrederi, Norway; length between perpendiculars 516ft, breadth moulded 73ft, depth moulded 41ft 1in, deadweight 18,250 tons on 30ft 6in draught, speed 14¼ knots; twenty-six cargo oil tanks; Sulzer, single-acting, two-stroke oil engine, nine cylinders, 720mm diameter by 1250mm stroke, 6300 b.h.p. at 125 r.p.m. Launch, July 22nd.

British Patent Specifications

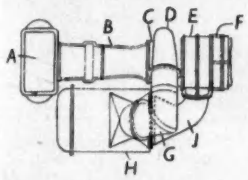
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

GAS TURBINES

711,439. December 6, 1951.—Cooling Systems of Gas Turbines, Raymond Ernest Wigg and Ruston and Hornsby, Ltd., both of Sheaf Ironworks, Lincoln.

The invention relates to the cooling of hot parts of a gas turbine, especially thin-walled ducts carrying hot gases at elevated pressures such as the ducting conveying the working fluid from the combustion



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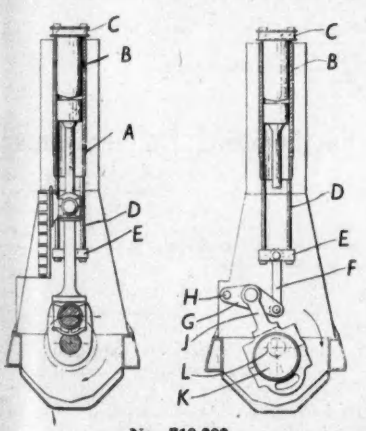
chamber to the first turbine stage. A plan view of the charging unit of a gas turbine is shown in the drawing. *A* is the air inlet casing, *B* the axial flow compressor and *C* an intermediate casing, combined with which is the compressor outlet volute *D*. The turbine inlet duct casing is shown at *E* and the turbine driving the compressor at *F*; *G* is an elbow connected to the compressor outlet volute *D*, which leads into the combustion chamber *H*. The exhaust from the turbine *F* forms the working fluid for the power turbine in which it is expanded. This power turbine is not illustrated as it does not form part of the invention. The specification and the accompanying drawings of the compressor driving turbine and the combustion chamber show clearly the arrangements made to fill the spaces between the duct conveying highly heated pressure gases and the pressure-resistant casings with porous lagging material. Passages are provided for conveying cooling air from the outlet of the space between the pressure resistant and the outer casings to the turbine stator casing. The cooling of ducts, by means of air bled from the compressor at a substantially lower pressure than the gas inside the duct, is also fully described and illustrated in the specification.—*June* 30, 1954.

INTERNAL COMBUSTION ENGINES

710,202. February 11, 1952.—Two-stroke Opposed Piston Engines, Aktieselskabet Burmeister and Wain's Maskin- og Skibsbyggeri, 4, Strandgade, Copenhagen.

The invention relates to a two-stroke engine of the type with a main piston controlling the inlet ports, as shown in the left-hand drawing, and a slide-



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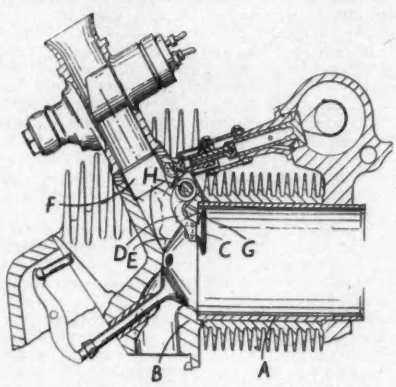
valve piston, of the same diameter working in counter phase, controlling the upper exhaust ports. According to the invention the transmission between the eccentrics and the slide-valve piston includes a lever system which is designed to greatly increase the stroke of the slide-valve piston. This is shown in the right-hand drawing. It will be seen that the engine which is of the multi-cylinder type has a cylinder open both ends provided with a lower ring of inlet ports *A* controlled by the main piston, and an upper ring of exhaust ports *B* controlled by the slide-valve piston. The slide-valve piston is mounted on a cross member *C* which, by means of four pull rods *D*, is connected to a pair of yokes *E*, arranged on either side of the main connecting-rod. Each of the yokes is connected in turn by means of a link *F*, to the free end of a lever arm *G*, which turns on a fulcrum pin *H*. Connected to this arm between its fulcrum and its free end is an eccentric strap *J*, the associated eccentric of which *K* is carried on the crankshaft adjacent to the main crank, and has its eccentricity set at 180 deg. to the main crank. The path of the eccentric is shown in a dotted line at *L*. For practical reasons it is not possible to make this circle larger than about one-third the diameter of the crank circle, but by including the lever arms *G* it is possible to increase the stroke of the slide-valve piston and to somewhat more than double its stroke.—*June* 9, 1954.

710,073. September 6, 1949.—Valve Gear, Archibald James Butterworth, 7, Grove Gardens, Frimley, Surrey.

An object of the invention is to provide a valve controlled passage which when the valve is open presents the minimum restriction to the flow of gas while retaining the proved reliability and mechanical



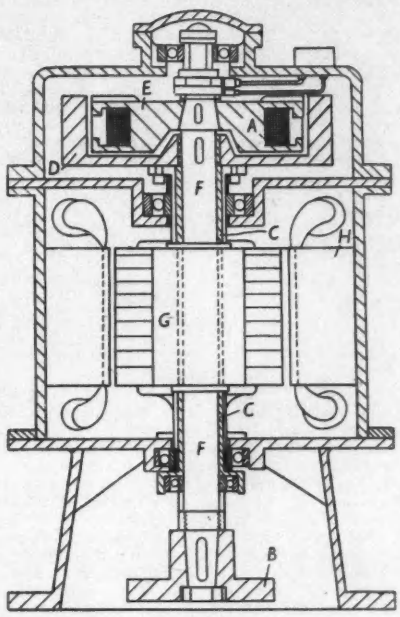
No. 710,073

simplicity of the poppet valve-head and its gas-sealing properties. As the drawing shows, the cylinder barrel *A* is spigoted into cylinder-head *B*, in which is formed a circular seat for the inlet valve-head *C*. This valve-head may be made in one piece with rocker arm *D*, or may be attached to rocker arm. As drawn, a short stem is passed through a hole in the rocker arm *D* and riveted over, to leave the valve-head *C* free to rotate, to facilitate grinding in, and so as also to accommodate the plane of its rim to that of the seat *E* in the cylinder-head. A curved rocker arm *D* protrudes into inlet passage *F*, through a narrow slot *G* across which lies rocker shaft *H*. The valve and rocker arm are shown in the open position in the drawing. Owing to the location of the valve-actuating gear, very low reciprocating weights can be attained without the inconvenience and expense of an overhead camshaft. It will be seen that the passage *F* has a straight, longitudinal axis and that the plane of the valve seat *E* is oblique to that axis. As the valve opens the angle its axis makes with the axis of the cylinder diminishes until when in the fully open position the valve axis is parallel to the cylinder axis as shown. The head of the valve is disposed to one side of the axis of the passage *F*, thereby presenting little obstruction to the flow of gases. The small obstruction presented by the rocker arm when the valve is in the open position may readily be made of streamline form and the small reduction in area compensated for. The inlet gases in passing the inclined valve-head have imparted to them a high degree of swirl or turbulence upon entering the cylinder.—*June* 9, 1954.

ELECTRICAL ENGINEERING

709,946. August 15, 1951.—Combined Electric Motor and Coupling, Drysdale and Co., Ltd., and John Young, of the company's address at Bon-Accord Works, Yoker, Glasgow.

The invention embodies a motor and the electromagnetic slip coupling in a single unit. The drawing shows the motor with a short-circuited rotor. The rotor shaft *C* is vertical and tubular and is journalled in upper and lower bearings. The magnetic slip coupling *A* is located above the upper end of the motor, the power take-up coupling *B* being below the lower end of the motor. The upper end of the tubular shaft *C* carries the secondary portion *D* of the magnetic slip coupling. The primary portion *E* of the coupling containing the excitation coils and the electromagnet is mounted on a power output shaft *F* passing through the tubular rotor shaft *C*. The shaft is supported on ball bearings as shown. As the magnetic slip coupling *A* is placed above the top of the electric motor, heat generated under conditions of slip can be easily dissipated. Ventilation means can be provided for the casing containing the magnetic slip coupling apart from the ventilation of the compartment containing the rotor *G* and the stator *H* of the motor. With the described



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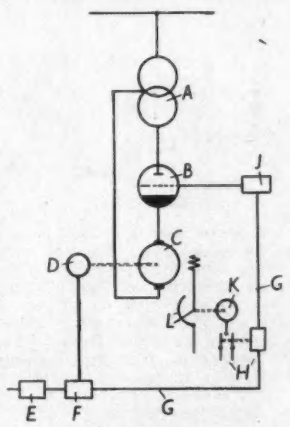
arrangement of the magnetic slip coupling *A* and rotor *G* variable speed can be achieved by altering the excitation of the primary portion *E* of the magnetic slip coupling. The arrangement is more particularly applicable to centrifugal pumps and fans for marine service, and is also applicable to a horizontal shaft motor without materially interfering with the basic features of the design.—*June* 2, 1954.

709,768. February 11, 1952.—Regulating the Speed of Rolling Mill Motors, Schloemann Aktiengesellschaft, Steinstrasse, Düsseldorf, Germany.

The invention relates to an arrangement for automatically regulating the speed of rolling mill motors supplied with current through grid-controlled rectifiers, the controlling range being increased by means of an additional motor field control. A transformer



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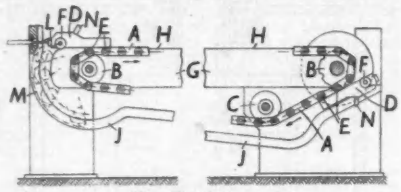
A is connected to the three-phase supply and the secondary voltage is rectified by the rectifier *B* and fed to the roll motor *C*. The motor is mechanically connected to an instrument *D* for determining the actual speed, while the instrument *E* for determining the required speed gives an electrical quantity, preferably voltage, equal to the required speed. The comparator *F* forms the difference between the actual speed and the required speed in the form of a corresponding electrical quantity which is connected through the conductor *G* to the relay *H* and to the grid-control instrument *J* for the rectifier *B* in parallel, whereby a variation is produced in the voltage applied to the motor in the sense of a reduction in the difference between the actual speed and the required speed. The relay *H* responds when the regulation through the grid exceeds or falls below a predetermined value. The response of the relay produces, through the motor *K*, an adjustment of the field regulator *L* and consequently an increase of the grid-control range.—*June* 2, 1954.

TOOLS AND WORKSHOP APPLIANCES

711,249. May 28, 1952.—DRAWBENCH WITH A CHAIN ROTATING CONTINUOUSLY IN THE SAME DIRECTION, Alfred Kreidler, 1, Gaensheidestrasse (14a), Stuttgart-O, Germany.

As shown in the drawing, the drawing chain *A* passes over the drive chain wheel *B* and over two guide wheels *C*. Two carriages *D* are each secured at their forward end by means of two eyes *E* to the draw chain. Each carriage is guided by an off-set roller *F* at the trailing end, which during the drawing operation rolls on the upper surface of the drawbench frame *G* forming a forward guide track *H* and during its return stroke rolls on an extension



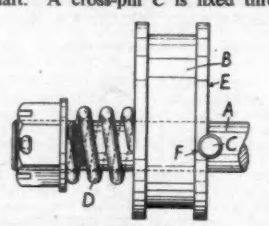
No. 711,249

of the track forming a lower return track *J*. On the draw-in side of the drawbench the drawing chain guides the carriage *D* from the return track into the draw line. Tongs *L* on a rearwardly projecting or off-set portion of the carriage pass through the shallow, substantially curved portion *M* of the return track. The open jaws of the tongs encompass the sharpened end of the work projecting out of the die ; and are closed by the operator by reversing a lever *N*, and the bar is gripped and the drawing operation begins. As soon as the bar is drawn out of the die the resistance holding the jaws of the tongs closed ceases and the jaws open. The carriage is swung at the end of the drawbench, around the chain wheel *B*, downwards on to the return track and returns to the draw-in side of the bench, where the cycle is repeated. The use of at least two carriages avoids wasted time.—*June* 30, 1954.

AGRICULTURAL ENGINEERING

710,246. October 7, 1952.—OVERLOAD RELEASE DEVICES FOR DRIVING SHAFTS, Geo. Monro, Ltd., Hertford Road, Waltham Cross, Hertfordshire. (*Inventor : Harry Thomas Shickle.*)

The invention relates to agricultural implements and is of particular use with comparatively light-load working implements driven by a small internal combustion engine. In the drawing the power driven shaft *A* is arranged to drive the implement member *B*, which is slidably and rotatably mounted on the shaft. A cross-pin *C* is fixed through the



No. 710,246

shaft *A* and the member *B* is urged by a spring *D* against the projecting ends. The face of the driven member which abuts the cross-pin is formed with a pair of recesses which are adapted to engage the ends of the cross-pin. The recesses are less than a semi-circle in order that should an excessive load be encountered by the driven element *B* the driving shaft will continue to rotate but the ends of the pin will ride out of the recesses *F*. The load of the spring may be adjusted by turning the compression nut on the shaft.—*June* 9, 1954.

NEW COURSE IN PRESS TOOL MAKING.—The City and Guilds of London Institute announces the adoption of a scheme for courses and examinations in a new subject (No. 186), press tool making. The scheme has been prepared by an advisory committee which includes representatives of the Institutions of Mechanical, Production, and Body Engineers, the Gauge and Tool Makers' Association, the Society of British Aircraft Constructors, the Amalgamated Engineering Union, the educational associations concerned with technical education, and the Ministry of Education. It is intended mainly for apprentice tool makers attending part-time courses extending over five years. The first two or three years will be occupied by preparation for the City and Guilds Intermediate Examination in Machine Shop Engineering, and the last two or three years by the special course in press tool making, which will comprise press tool technology, workshop practice, science, and design appreciation. The scheme suggests practical exercises and appropriate workshop equipment for colleges providing the courses. It starts in September, 1954. Details may be obtained from the Department of Technology, City and Guilds of London Institute, 31, Brechin Place, South Kensington, London, S.W.7.

Technical Reports

The Impedance of Steel Conduit used as an Earth-Continuity Conductor. (Ref. V/T111.) By A. Butterworth, B.Sc. (Eng.), A.M.I.E.E., L. Gosland, B.Sc., M.I.E.E., and G. F. Shotter, M.I.E.E. The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 12s., postage 4d.—The purpose and implications of the change made in the 12th Edition of the Institution of Electrical Engineers Wiring Regulations, from the limitation of the resistance of an earth-continuity conductor to 1 ohm, to the limitation of its impedance to this value, are examined in this report, with reference to steel conduit systems. It is shown that such a system has several impedances and the significance of each with regard to the safety of the installation is analysed. Recommendations are made as to the most appropriate method of specifying and measuring the electrical characteristics of a steel-conduit installation with a view to ensuring that it shall contribute effectively and permanently to earthing requirements.

Flameproof Electrical Apparatus : Flanged Joints, One Inch and One Half-Inch in Radial Breadth, in Atmospheres of Pentane Vapour and Air. (Ref. G/T291.) By H. Robinson and H. L. Williams. The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 10s. 6d., postage 3d.—This report deals with tests to determine the effect on the maximum experimental safe gap with pentane air mixtures when the radial breadth of the flanges of the 8-litre sphere used is reduced from 1in to ¼in. The conclusions also refer to the more rigorous test methods now used, as compared with those employed in 1938.

Ferromagnetic Domain Processes in Single Crystals of Silicon Iron. (Ref. N/T65.) By D. H. Martin, B.Sc. The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 4s. 6d., postage 3d.—An account is given here of an investigation of the effects of imperfections, such as pits in the surface, on domain magnetisation processes in silicon iron. The work was done in the Physics Department of the University of Nottingham.

A Note on the Use of Electrode Potentials for the Estimation of Corrosion due to Dissimilar Metal Contact. (Ref. O/T11.) By G. Mole, Ph.D. The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 7s. 6d., postage 3d.—This report is intended to serve as a guide to the underlying principles governing the corrosion resulting from contact of dissimilar metals. Static equilibrium charts for combinations which are of particular interest in corrosion problems are included. References to work in the field of metallic corrosion are given.

Research into the Properties of the Hydrogen Oxygen Cell. (Ref. Z/T94.) By F. T. Bacon, M.A., A.M.I.Mech.E. The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 10s. 6d., postage 3d.—This report continues the work described in Ref. Z/T81 to the stage where the difficult problem of corrosion of the electrodes is nearly solved. Other problems to be investigated are listed and a brief review given of possible applications of the cell in industry.

Development of a Specification for a Discharge ("Ozone") Resistance Test for Rubber Insulated Cables. (Ref. F/T180.) The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 7s. 6d., postage 3d.—An investigation has been carried out to develop a type test for discharge ("ozone") resistance of rubber insulated cables for electric power and lighting for inclusion in a revision of B.S.7. It was agreed that this test should be developed on the general lines of that prescribed in B.S. E.20 : "High Tension Ignition Cables for Aircraft Engines," i.e. a test voltage would be applied between the conductor of the cable (stripped of its outer protective coverings) and a suitable external electrode so as to produce a layer of corona discharge at the surface of the rubber insulation.

In the test included in B.S. E.20 several turns of the cable are wound on a wooden mandrel which is then inserted in a brass tube so as to leave a small air gap between the tube and the rubber. A voltage 25 per cent in excess of the rated voltage of the cable is then applied for four hours between the tube and the cable conductor. It is required that no breakdown or visible damage to the rubber shall occur in that time.

Consideration is given to the modifications which are required to make such a test appropriate to the type of cable and range of sizes covered by B.S.7.

Flameproof Enclosures—Effect of Size and Shape of Enclosure on the Maximum Experimental Safe Gap. (Ref. G/T289.) By C. E. R. Bruce, D.Sc., M.I.E.E. The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 6s., postage 3d.—At the Meetings of the I.E.C. Technical Committee (No. 31) held in London in April, 1953, some delegates questioned the general applicability of the data obtained by the use of a spherical vessel in the determination of safe flange gaps, and the Chairman invited the British delegation to discuss the following points which summarised those raised in the discussion : (1) The probable effect of using test vessels other than spheres and of using different shaped vessels partly filled with equipment to simulate practical conditions. (2) Whether the one-in-a-million chance accepted as the greatest risk with spheres could, on the basis of present knowledge, also be associated with other shapes. (3) The effect of using test vessels equal in volume to the size of the enclosures in service—for example, would the dispersal of results produce curves similar to those found with the 8-litre test spheres ?

A search has now been made through the available E.R.A. reports, and other published papers, and a summary of the results is given in this report.

Creep Properties of Steels Utilised in High Pressure and High Temperature Superheater and Steam Pipe Practice. Part III.—Revision of Long Time Creep Data for a Carbon Steel Header and a Carbon-Molybdenum Steel Pipe. (Ref. J/T156.) By R. W. Ridley, B.Sc. (National Physical Laboratory). The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 10s. 6d., postage 4d.—In Parts I and II of this series of reports estimated temperatures for 0·1 to 0·5 per cent creep in periods up to 100,000 hours for three carbon and three carbon-molybdenum steels were given, over a selected range of stress, obtained by logarithmic extrapolation of creep tests of less than 10,000 hours' duration. This report gives revised temperature estimates for one carbon superheater header at 5 tons per square inch and for one carbon-molybdenum steam pipe steel at 6 tons per square inch, based on the results of creep tests at these stresses lasting 67,000 hours. The extended tests indicate that modifications are necessary in the previously extrapolated temperatures corresponding to 100,000 hours. The two tests are being continued for the full time of 100,000 hours.

Catalogues

JAMES NEILL AND CO. (SHEFFIELD), Ltd., Napier Street, Sheffield, 11.—Leaflet giving particulars of the new "20T" hack saw frame.

FOURWAYS (ENGINEERS), Ltd., Thornwood Common, Epping, Essex.—Leaflet illustrating Fourways electrical mobile conveyors.

HACKBRIDGE AND HEWITTIC ELECTRIC COMPANY, Ltd., Walton-on-Thames, Surrey.—Publication No. R249, illustrating Hewitic selenium rectifier equipments.

CROWTHORN ENGINEERING COMPANY, Ltd., Atlas Works, Reddish, Nr. Stockport.—Leaflet dealing with 30in and 36in swing boring and facing lathes.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., 21, Bloomsbury Street, London, W.C.1.—Publication No. 335, describing and illustrating earthing equipment.

ROYCE ELECTRIC FURNACES, Ltd., Sir Richards Bridge, Walton-on-Thames, Surrey.—Publication illustrating and describing general purpose box-type furnaces.

HOWARD PNEUMATIC ENGINEERING COMPANY, Ltd., Fort Road, Eastbourne, Sussex.—Leaflet illustrating and giving details of Howard stainless steel centrifugal pumps for the chemical and food industries.

SOAG MACHINE TOOLS, Ltd., Juxon Street, Lambeth, London, S.E.11.—Leaflets : "Machine Tools You May Want." "Planing Machines Stock List," "Lathes Stock List," "W.G.W. Keyseaters," and "Stellamatic Drill."

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASLIB

Fri. to Mon., Sept. 24th to 27th.—Church House, Westminster, London, S.W.1, 29th Annual Conference.

INCORPORATED PLANT ENGINEERS

Tues., Sept. 7th.—LONDON BRANCH : Royal Society of Arts, John Adam Street, London, W.C.2. Open Forum, 7 p.m.

Wed., Sept. 1st.—LEICESTER BRANCH : Bell Hotel, Leicester, "The Works Engineer and the Factories Act," H.M. District Inspector of Factories, 6.30 p.m.

Thurs., Sept. 9th.—NORTH EAST BRANCH : Roadway House, Oxford Street, Newcastle upon Tyne, "The Engineering Application of Electro-Deposited Metals," J. W. Oswald, 7 p.m.

Wed., Sept. 15th.—KENT BRANCH : Bull Hotel, Rochester, Kent, "The Causes and Prevention of Steam Plant Scale," W. F. Gerrard, 7 p.m.—WESTERN BRANCH : Grand Hotel, Bristol, "Planning and Reconstruction of Bristol," R. W. Jefford, 7.15 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Tues., Aug. 17th.—Visit by a Party of Members to the Works of the Vacuum Oil Company, Ltd., Wandsworth, 2 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Wed. to Sun., Aug. 25th to 29th.—Ashorne Hill, Warwickshire, Fifth Annual Summer School of Production Engineering.